ARR No. L5B17

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED

April 1945 as
Advance Restricted Report L5B17

WIND-TUNNEL INVESTIGATION OF A RECTANGULAR

NACA 2212 AIRFOIL WITH SEMISPAN AILERONS AND WITH

NONPERFORATED, BALANCED DOUBLE SPLIT FLAPS

FOR USE AS AERODYNAMIC BRAKES

By Thomas A. Toll and Margaret F. Ivey

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

ADVANCE RESTRICTED REPORT

WIND-TUNNEL INVESTIGATION OF A RECTANGULAR

NACA 2212 AIRFOIL WITH SEMISPAN AILERONS AND WITH

NONPERFORATED, BALANCED DOUBLE SPLIT FLAPS

FOR USE AS AERODYNAMIC BRAKES

By Thomas A. Toll and Margaret F. Ivey

SUMMARY

Tests have been made in the Langley 7- by 10-foot tunnel to determine the applicability of nonperforated, balanced double split flaps for use as aerodynamic brakes. Information was desired on the braking power of the flaps as well as on the effectiveness and the stability of a conventional trailing-edge aileron located immediately behind the flaps.

A rectangular 10- by 60-inch wing model of NACA 2212 airfoil section was used for the tests. Results were obtained for flat-plate flaps with no wing cut-outs and for flaps having Clark Y sections with cut-outs made in the wing to simulate the space left open by the deflected flaps. The flap deflections, the chordwise location, and the gaps between the flaps and the airfoil contour were varied over wide ranges in order to determine the optimum configuration. In addition to the force tests, an investigation was made to determine any buffeting tendencies of the aileron. Silk tufts and a flexible torque rod were used for these tests.

The drag was only slightly lower for the model having airfoil-section flaps and wing cut-outs than for the model having flat-plate flaps and no cut-outs in the wing; for both arrangements the drag was higher than that obtained in previous tests of an NACA 23012 airfoil with full-span, 0.20-airfoil-chord, perforated double split flaps. The aileron effectiveness was low in either case, except when the flap gaps were equal to about 20 percent of the wing chord and when the noses of the flaps were at least 80 percent of the chord from the leading edge of the wing.

Although the entire model showed some tendency to
shake, tufts indicated that the air flow over the aileron
generally was smooth. Tests of the aileron attached to
a flexible torque rod indicated almost no tendency for
the aileron to shake; however, when the flap gaps were
15 percent of the wing chord or less, the aileron acted
as though it were overbalanced and usually tended to
float against the stops for either positive or negative
deflections.

INTRODUCTION

The present investigation was made because certain
unpublished data had indicated that satisfactory drag
and lateral control characteristics had been obtained on
an airplane with balanced double split flaps mounted
ahead of a conventional aileron. Tests of balanced single
split flaps on the lower surface of a wing had previously
been made by the NACA (reference 1), and certain flap
locations were found at which the aileron was as effec-
tive with flap deflected as with flap retracted. Tests
of perforated double split flaps having no gaps between
the flaps and the airfoil contour (references 2 to 5)
showed that such flaps produced desirable lift, drag, and
pitching-moment characteristics for use as dive brakes
and that the drag increment increased as the flaps were
moved forward on the wing. The tests reported in refer-
ence 2, however, showed that almost no effectiveness
could be expected from an aileron located behind these
flaps.

The present tests were made with a model configura-
tion similar to that of references 2 and 4 but having
two flaps, similar to the flap of reference 1, symmetri-
cally disposed above and below the wing. It was desired
to determine if there were any flap locations at which
sufficient lateral control as well as satisfactory drag
characteristics could be obtained simultaneously.

APPARATUS AND TESTS

Model

The wing model was built of mahogany to the NACA 2212
profile. The model was of rectangular plan form; the span

was 60 inches and the chord, 10 inches. Semispan ailerons
having chords equal to 18.5 percent of the wing chord
(0.185c) were provided. The ailerons were not balanced
and had small gaps at their leading edges.

Two sets of flaps were used with the model. Both
sets were full span, were nonperforated, and had chords
of 2 inches. One set was made of flat steel plate
$\left(\frac{1}{16}\text{-in. thick}\right)$ and had rounded leading edges. Each flap
of this set was attached to the wing by eight fittings
along the span. The fittings were adjustable to allow
variations of flap deflections, chordwise locations, and
gaps between the flaps and the wing. The wing had no
cut-outs to simulate the space left by the flaps when
deflected. Photographs of the model mounted in the
tunnel are given as figures 1 and 2. The second set of
flaps was constructed of steel plate and wood to the
Clark Y section (fig. 3). Cut-outs in the wing were made
to simulate the space left by the flaps when deflected.
Each flap was attached to the wing by six fittings, which
rested on narrow bridges left across the wing cut-outs.

The dimensions of the model and the flap locations
and deflections tested are given in figures 4 and 5.

Tests

The dynamic pressure maintained for all tests was
16.37 pounds per square foot, which corresponds to a
velocity of about 80 miles per hour under standard sea-
level conditions and to a test Reynolds number of 609,000
based on the chord of the model wing (10 in.). The effec-
tive Reynolds number, based on a turbulence factor of 1.6
for the Langley 7- by 10-foot tunnel, was about 975,000.

The tests consisted principally of the determination
of the lift, drag, and pitching-moment characteristics
of the model with the ailerons neutral and of the rolling-
and yawing-moment characteristics of the model with the
right aileron at various fixed deflections. A few tests
were made to determine the aileron hinge-moment coeffi-
cients and to investigate the flow conditions in the
vicinity of the aileron.

Tests of the model with no wing cut-outs and with flat-plate flaps were made with the flaps at a number of chordwise locations, gaps, and deflections. Only a few configurations of the model with airfoil-section flaps and with wing cut-outs were tested. These tests were made principally to check the validity of the assumption that the wing cut-outs and the flap section would have little effect on the results when the flaps are at high deflections.

RESULTS AND DISCUSSION

Symbols

In the presentation of the results, the following symbols are used:

C_L lift coefficient (L/qS)

C_D drag coefficient (D/qS)

$C_{m_{c/4}}$ pitching-moment coefficient about quarter-chord point of airfoil $\left(\dfrac{M_{c/4}}{qSc}\right)$

C_h aileron hinge-moment coefficient $\left(H/qb_a c_a^2\right)$

C_l' rolling-moment coefficient (L'/qSb)

C_n' yawing-moment coefficient (N'/qSb)

where

L lift

D drag

H aileron hinge moment

$M_{c/4}$ pitching moment about quarter-chord point of airfoil

L' rolling moment about wind axis in plane of symmetry of model

N'   yawing moment about wind axis in plane of
              symmetry of model

q   dynamic pressure of free air stream $\left(\dfrac{\rho V^2}{2}\right)$

ρ density

V   velocity

c   wing chord

c_a aileron chord

S   wing area

b   wing span

b_a span of aileron

α angle of attack

δ_a aileron deflection

δ_{f_U} upper-surface split-flap deflection measured
              from wing chord line

δ_{f_L} lower-surface split-flap deflection measured
              from wing chord line

Gap is defined as the distance, measured perpen-
dicular to the wing chord line, between the true airfoil
contour and the portion of the flap nearest the airfoil
contour. (See figs. 4 and 5.)

Chordwise location is defined as the distance,
measured parallel to the wing chord line, between the
wing leading edge and the tangent - perpendicular to the
wing chord line - to the portion of the flap nearest the
airfoil contour. (See figs. 4 and 5.)

Aileron effectiveness is defined as the increment
of rolling-moment coefficient between curves corresponding
to two fixed aileron deflections.

                        Corrections

No corrections were applied for the effects of
support-strut interference. The standard jet-boundary

corrections, which were applied to all the force-test data, are:

$$\Delta\alpha = \delta\frac{S}{C}c_L\ 57.3$$

$$\Delta c_D = \delta\frac{S}{C}c_L{}^2$$

where $\Delta\alpha$ is in degrees, δ is the jet-boundary correction factor, and C is the cross-sectional area of the jet (69.59 sq ft). A value of $\delta = 0.112$ for the closed-throat wind tunnel was used in correcting the results. No corrections were applied to the pitching-, yawing-, rolling-, or hinge-moment coefficients; these corrections are all small because of the relatively small size of the model.

Wing without Flaps

Tests were made of the model without flaps in order to provide a basis upon which to compare the tests of the model with flaps. The results of these tests are given in figures 6 to 8. The almost linear variation of lift coefficient with angle of attack (fig. 6), the large and almost constant increment of rolling-moment coefficient between aileron deflections of ±20° (fig. 7), and the approximately constant negative slope of the hinge-moment curves (fig. 8) should be noted.

Wing with Flat-Plate Flaps

The model was tested with two symmetrically located flat-plate flaps at a number of chordwise locations, gaps, and deflections. The results of the tests are given in figures 9 to 20. The effect of flap deflection (flaps located at 0.80c and with 0.05c gaps) is given in figure 9. A comparison of this figure with figure 6 indicates that, at zero angle of attack, increments of drag coefficient of 0.232 and 0.468 are produced by the flaps when deflected 30° and 60°, respectively. Comparable values of the drag increment caused by full-span, 0.20c, perforated double split flaps at the same chordwise

location on an NACA 23012 airfoil (fig. 3 of reference 2)
are 0.14 and 0.33. The irregularities in the curves
of C_L against α for the model with flaps deflected
(fig. 9) are of interest. The effectiveness of the
ailerons is very low - at times, even negative - for this
configuration (fig. 10).

When the flaps are deflected 30°, the irregularities
in the curve of C_L against α are less pronounced when
the gaps are 0.10c (fig. 11) than when the gaps are 0.05c
(fig. 9). The aileron effectiveness is greater when the
gaps are 0.10c (fig. 12) than when the gaps are 0.05c
(fig. 10). Increasing the flap deflection to 60° results
in large irregularities in the curves of C_L against α
(fig. 13) as well as in reductions in the lift-curve
slopes, particularly when the flaps are located far for-
ward. The aileron effectiveness (fig. 14) is generally
lower and more irregular when flaps are deflected 60°
than when flaps are deflected 30° (fig. 12). Tests were
made with aileron deflections of ±10° as well as 0°
and ±20° for the condition of the flaps located at 0.80c
(fig. 14(c)), in order to determine if greater effective-
ness might be obtained at the smaller aileron deflections.
The effectiveness seems to increase almost linearly with
deflection for low angles of attack but is about the same
for $\delta_a = \pm 10°$ as for $\delta_a = \pm 20°$ at high angles of
attack.

The characteristics of the model with the flaps
deflected 60° and with gaps of 0.15c are given in fig-
ures 15 and 16. The irregularities in the lift curves
increase in magnitude as the flaps are moved forward
(fig. 15). The aileron effectiveness decreases as the
flaps are moved forward (fig. 16).

With the flaps located at 0.80c and with gaps
of 0.20c, tests were made with the flaps deflected 60°,
90°, and 120° (figs. 17 and 18). The lift curves for
the conditions of flaps deflected 60° and 120° are char-
acterized by flat regions near zero angle of attack
(fig. 17). When the flaps were deflected 90°, an irregu-
larity occurred, which was similar to those noted previ-
ously. The maximum values of the lift-curve slopes for
these conditions are only about one-half the value of
the lift-curve slope for the model without flaps
(fig. 6). The aileron effectiveness is relatively high

(about 80 percent of the effectiveness when no flaps are
attached) and does not seem to be appreciably affected
by the flap deflection (fig. 18).

Tests were made with flap chordwise locations
of 0.90c, gaps of 0.20c, and deflections of 60° and 120°.
The results are given in figures 19 and 20. The condition
of flaps deflected 60° seems to be the most favorable of
all the configurations that have been discussed. The lift
curve (fig. 19) is almost linear and the value of its
slope for angles of attack greater than 2° is about
80 percent of the value of the lift-curve slope of the
model without flaps (fig. 6). The ailerons are as
effective as when no flaps are attached.

Tests were made with one flap located at 0.80c,
with a 0.10c gap, and with a deflection of 60° (figs. 21
and 22). For the negative angle-of-attack range with
the flap placed below the airfoil and for the positive
angle-of-attack range with the flap placed above the
airfoil, the effectiveness of the aileron for ±20°
deflection is about the same as the effectiveness when
no flaps are attached. When the flap is below the
airfoil, the effectiveness of the aileron deflected 20°
decreases as the angle of attack is increased above -2°
(fig. 22(a)). When the flap is above the airfoil, the
effectiveness of the aileron deflected -20° decreases as
the angle of attack is decreased below -2° (fig. 22(b)).

Wing with Airfoil-Section Flaps

The results of tests of the model with Clark Y
airfoil-section flaps are given in figures 23 to 37.
The lift, drag, and pitching-moment characteristics of
the model with flaps deflected 30° and at chordwise
locations of 0.60c and 0.70c are given in figure 23(a)
for flap gaps of 0.05c and in figure 23(b) for flap gaps
of 0.10c. A comparison of the curves for the 0.70c
location of figure 23(b) with the corresponding curves
of figure 11 reveals that the airfoil-section flaps and
wing cut-outs result in slight decreases in the drag
coefficients. A similar effect through most of the
angle-of-attack range may be noted by comparing figures 27,
29, and 31 with figures 13, 15, and 17, respectively.
Part of the reduction in drag coefficient is probably a
result of the fact that fewer fittings were used to
attach the airfoil-section flaps to the wing than were

used to attach the flat-plate flaps to the wing. The
aileron effectiveness generally is slightly higher for
the model having airfoil-section flaps and wing cut-outs
than for the model having flat-plate flaps and no cut-outs
in the wing; this fact can be noted by comparing figures 28,
30, and 32 with figures 14(a) and 14(b), 16(b) and 16(c),
and 18(a), respectively.

The variation of the rolling-moment coefficient with
aileron deflection was determined for the model with the
flaps located at 0.70c and with gaps of 0.15c and 0.20c
(fig. 33). At an angle of attack of 0° the rolling-
moment coefficient varied almost linearly with aileron
deflection, but at an angle of attack of 12.1° the
variation with negative deflections was irregular when
the gaps were 0.15c.

Aileron hinge moments were measured for a number of
model configurations and are presented in figures 34
and 35. When the flap gaps were 0.15c or less, the
aileron seemed to be overbalanced and usually tended to
float against the stops for either positive or negative
deflections. With the flaps located at 0.70c or at 0.80c,
the overbalance was eliminated by increasing the gaps
to 0.20c. At an angle of attack of 0° and at small
aileron deflections, the slope $\partial C_h / \partial \delta_a$ was still
considerably less negative, however, than when no flaps
were attached to the model (fig. 8).

Because the model had a tendency to shake when the
flaps were deflected 60° or more, an investigation was
made to determine if this shake were accompanied by a buffeting
tendency of the aileron. No such tendency was noted when
the aileron was restrained only by the flexible torque
rod used for the hinge-moment measurements. The investi-
gation was extended by observing silk tufts mounted from
masts attached to the aileron at its midspan, midchord
location. The directions and the stability of the various
tufts are indicated in figure 36 for several model
configurations. The tufts on and near the surfaces of
the aileron were almost invariably smooth and were pointed
in the downstream direction. Aileron buffeting therefore
does not seem to be a serious problem for an airplane
with balanced double split flaps.

A summary of the effects of gap and of chordwise
location of the two sets of flaps (each set at deflec-
tions of 60°) on the aileron effectiveness relative to

that of the plain wing and on the drag coefficients is
presented in figure 37. The aileron effectiveness
increases as the gaps are increased and as the flaps are
moved rearward. The drag increases as the gaps are
increased and as the flaps are moved forward. The varia-
tion in drag is probably caused by the increased depth
of the wake as the flaps are moved forward while constant
gaps are maintained between the flaps and the surfaces
of the wing and also by the higher local velocities
occurring at the forward portions of the wing. Refer-
ence 5 showed that the increment of drag caused by perfo-
rated double split flaps was more than doubled when the
flaps were moved from the wing trailing edge to the
0.30c location. From the results of the tests reported
herein, however, the 0.30c location would be expected to
result in little or no effectiveness of ailerons located
back of the flaps, even though the gaps were large.
Because the reduction in drag as the flaps are moved
rearward of the 0.60c location is not very great and
because the rearward flap locations result in improve-
ments in the other wing and aileron characteristics, it
seems desirable to locate balanced double split flaps at
about 0.80c or farther rearward. Gaps of about 0.20c are
necessary to obtain satisfactory wing lift, aileron-
effectiveness, and aileron hinge-moment characteristics.

CONCLUSIONS

From the results of tests of full-span, nonperfo-
rated, balanced split flaps on a rectangular NACA 2212
airfoil, the following conclusions may be drawn:

1. The effectiveness of a conventional aileron
behind balanced double split flaps was generally low but
increased as the flaps were moved rearward and as the
gaps between the flaps and the airfoil surfaces were
increased.

2. The drag of the model increased as the flaps were
moved forward and as the flap gaps were increased.

3. There was usually an irregularity in the curve
of lift coefficient against angle of attack for the
model with balanced double split flaps deflected. The
magnitude of the irregularity increased as the flaps

were moved forward, as the flap gaps were decreased, and as the flap deflections approached 90°.

4. The slope of the curve of lift coefficient against angle of attack generally decreased as the flaps were moved forward and as the flap gaps were increased.

5. An aileron back of a balanced single split flap with a small flap gap may be as effective through a large part of the angle-of-attack range as an aileron on a wing having no flaps.

6. The effectiveness of the aileron on the model having airfoil-section flaps and wing cut-outs was generally slightly higher than the effectiveness of the aileron on the model having flat-plate flaps and no wing cut-outs.

7. The drag of the model having airfoil-section flaps and wing cut-outs was generally slightly lower than the drag of the model having flat-plate flaps and no wing cut-outs.

8. Although the model with balanced double split flaps showed some tendency to shake, the aileron was usually steady and the air flow was smooth on and near the surface of the aileron.

9. Plain ailerons back of balanced double split flaps acted as though they were highly overbalanced when the flap gaps were 15 percent of the wing chord or less.

10. From a consideration of lift, drag, aileron-effectiveness, and aileron hinge-moment characteristics, a satisfactory practical configuration probably could be obtained with balanced double split flaps located at 80 percent of the wing chord and with flap gaps of 20 percent of the wing chord.

11. The drag of this model was higher than the drag of an NACA 23012 airfoil with full-span, 0.20-airfoil-chord, perforated double split flaps at the same chord-wise location.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCES

1. Rogallo, F. M., and Lowry, John G.: Wind-Tunnel
     Investigation of a Plain Aileron and a Balanced
     Aileron on a Tapered Wing with Full-Span Duplex
     Flaps. NACA ARR, July 1942.

2. Purser, Paul E., and Turner, Thomas R.: Wind-Tunnel
     Investigation of Perforated Split Flaps for Use as
     Dive Brakes on a Rectangular NACA 23012 Airfoil.
     NACA ACR, July 1941.

3. Purser, Paul E., and Turner, Thomas R.: Wind-Tunnel
     Investigation of Perforated Split Flaps for Use as
     Dive Brakes on a Tapered NACA 23012 Airfoil.
     NACA ARR, Nov. 1941.

4. Purser, Paul E., and Turner, Thomas R.: Aerodynamic
     Characteristics and Flap Loads of Perforated Double
     Split Flaps on a Rectangular NACA 23012 Airfoil.
     NACA ARR, Jan. 1943.

5. Blenkush, Philip G., Hermes, Raymond F., and Landis,
     Merle A.: Effect of Dive Brakes on Airfoil and
     Airplane Characteristics. Jour. Aero. Sci.,
     vol. 11, no. 3, July 1944, pp. 254-260.

NACA
LMAL
36117

Figure 1.- Three-quarter rear view of the 10- by 60-inch rectangular NACA 2212
    airfoil with full-span, nonperforated, balanced double split flaps of
    20-percent airfoil chord mounted in the Langley 7- by 10-foot tunnel. Flat-
    plate flaps deflected 60° and located at 0.60c with gaps of 0.15c; right
    aileron deflected.

Fig. 1
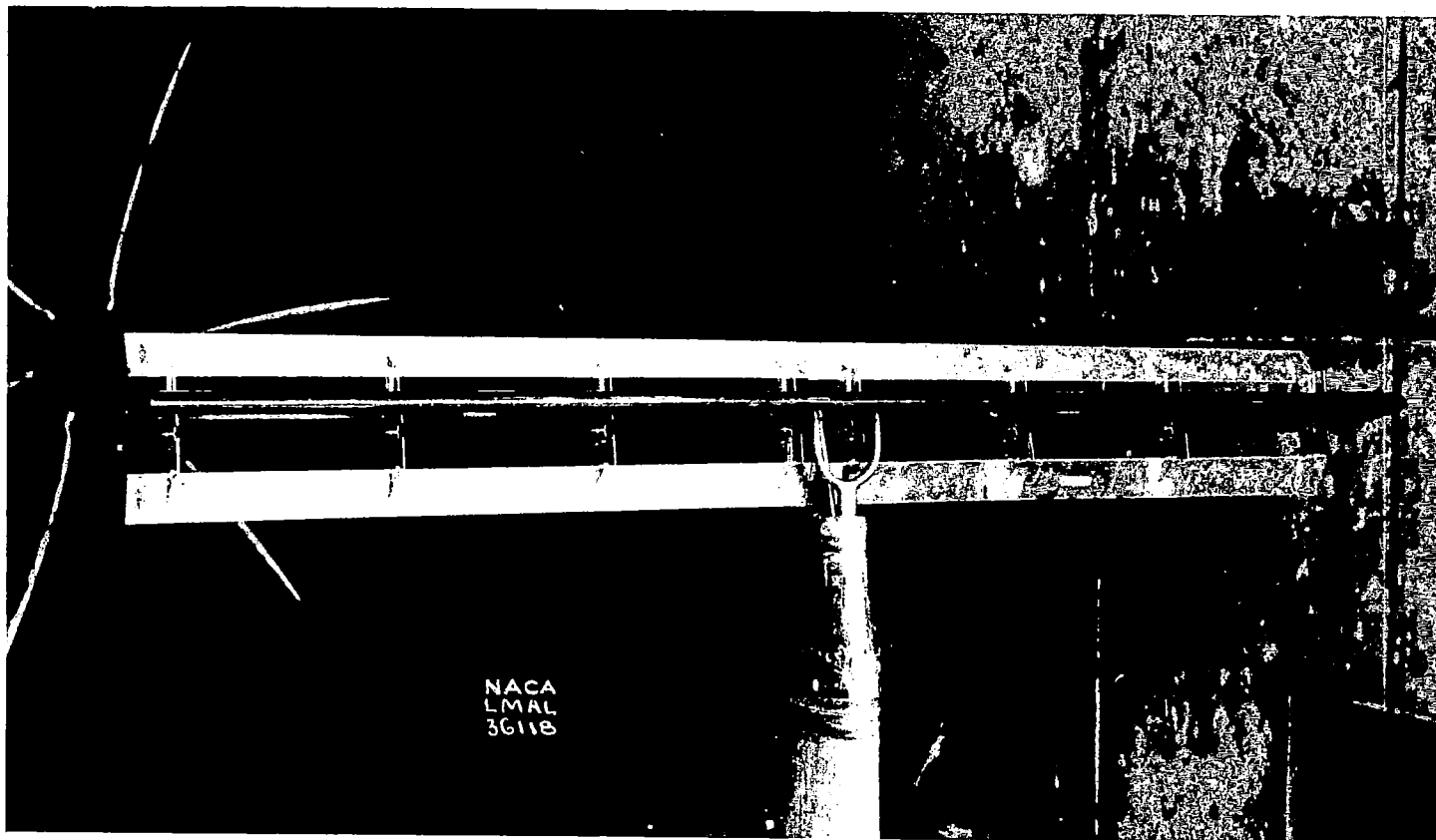
Figure 2.- Three-quarter front view of the 10- by 60-inch rectangular NACA 2212 airfoil with full-span, nonperforated, balanced double split flaps of 20-percent airfoil chord mounted in the Langley 7- by 10-foot tunnel. Flat-plate flaps deflected 60° and located at 0.60c with gaps of 0.15c; right aileron deflected.

Fig. 2
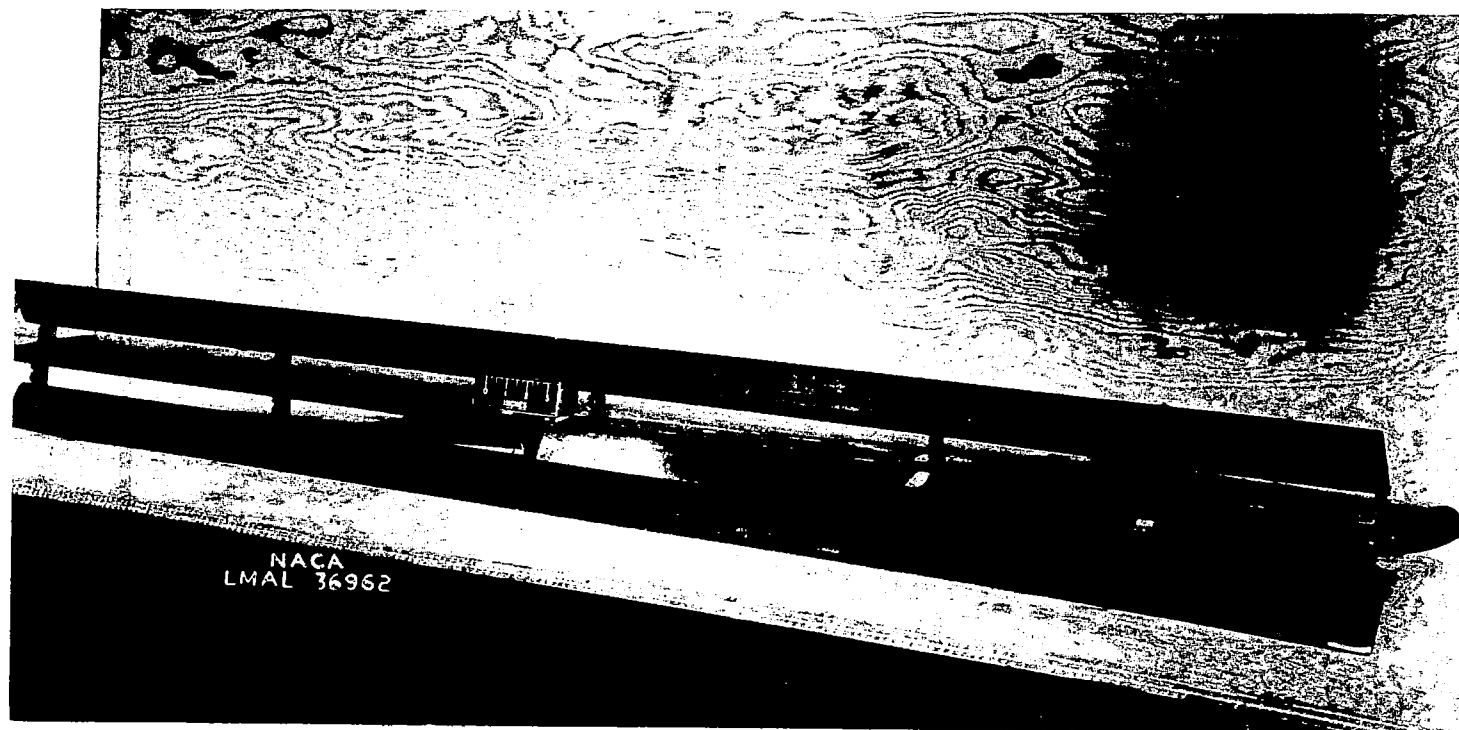
Figure 3.- Three-quarter rear view of the 10- by 60-inch rectangular NACA 2212 airfoil with full-span, nonperforated, balanced double split flaps of 20-percent airfoil chord. Airfoil-section flaps deflected 60° and located at 0.70c with gaps of 0.10c; right aileron deflected.

Fig. 3
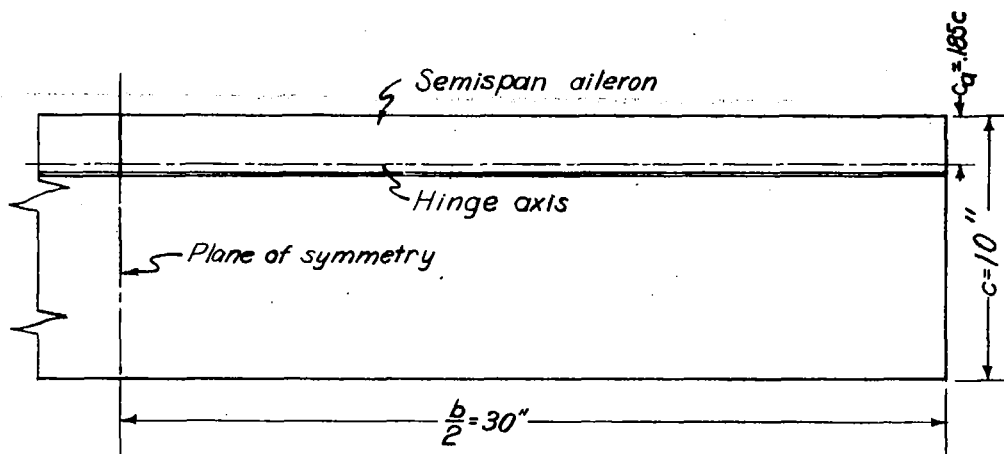
(a) Plan form of wing.
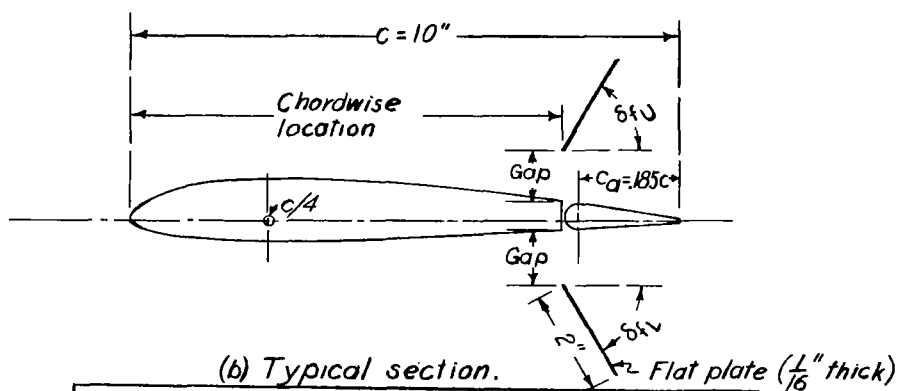
(b) Typical section.

Chordwise location Gap	0.60c	0.70c	0.80c	0.90c
0.05c			30 and 60	
.10c	60	30 and 60	30 and 60	
.15c	60	60	60	60
.20c			60,90,and 120	60 and 120

$\delta_{f_U} = \delta_{f_L}$ (deg)

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS.

(c) Flap deflections for various chordwise locations and gaps.

Figure 4.- Dimensions and flap configurations of the model
with balanced double split flaps having flat-
plate sections. Wing airfoil section, NACA 2212.

(a) Plan form of wing.

(b) Typical section.

Gap / Chordwise location	$\delta_{f_U} = \delta_{f_L}$ (deg)		
	0.60c	0.70c	0.80c
0.05c	30 and 60	30 and 60	
.10c	30 and 60	30 and 60	
.15c	60	60	60
.20c		60	60

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

(c) Flap deflections for various chordwise locations and gaps.

Figure 5.- Dimensions and flap configurations of the model with balanced double split flaps having Clark Y sections. Wing airfoil section, NACA 2212.
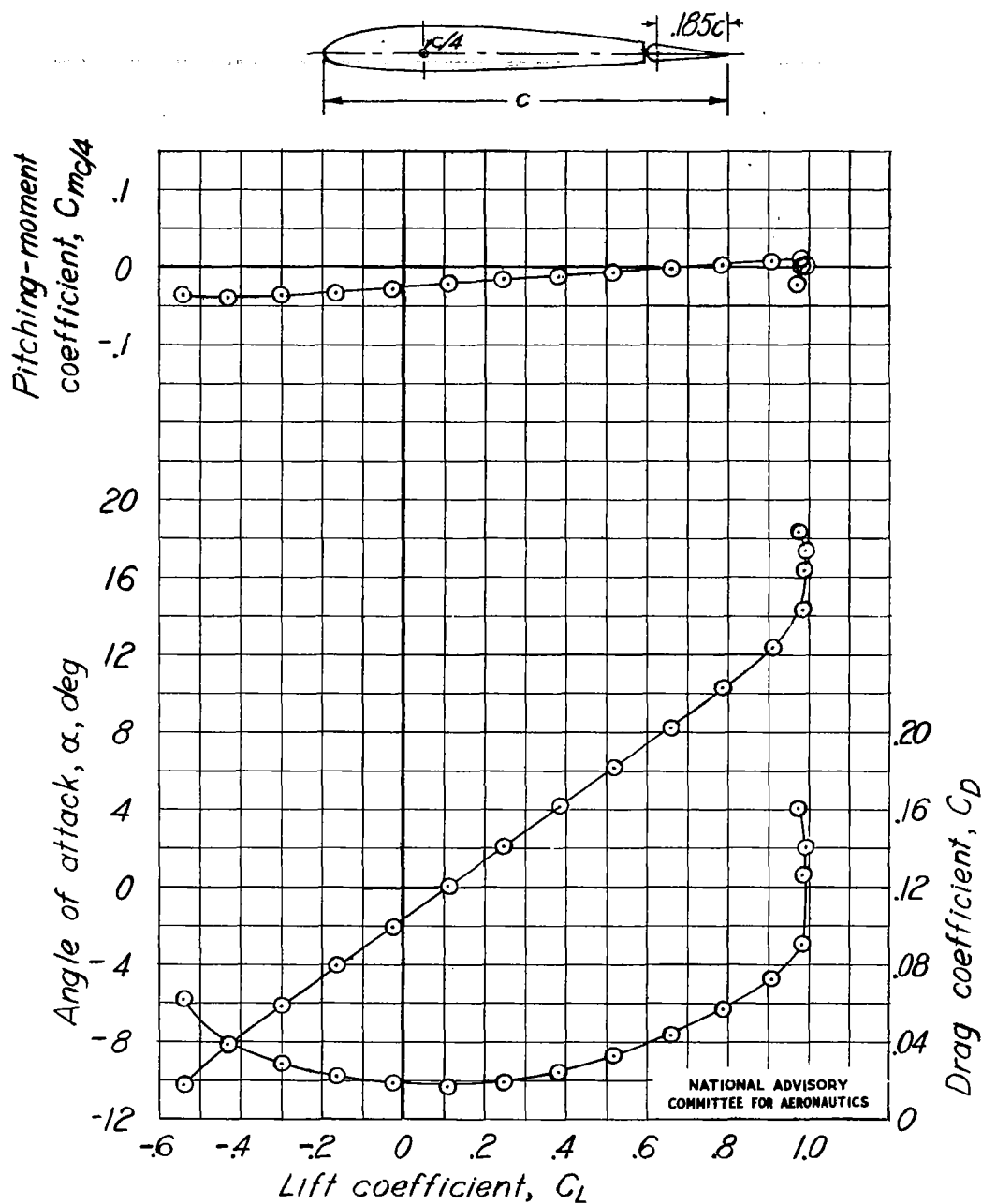
Figure 6.- Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model. No flaps; δ_a, 0°.

Fig. 7   NACA ARR No. L5B17
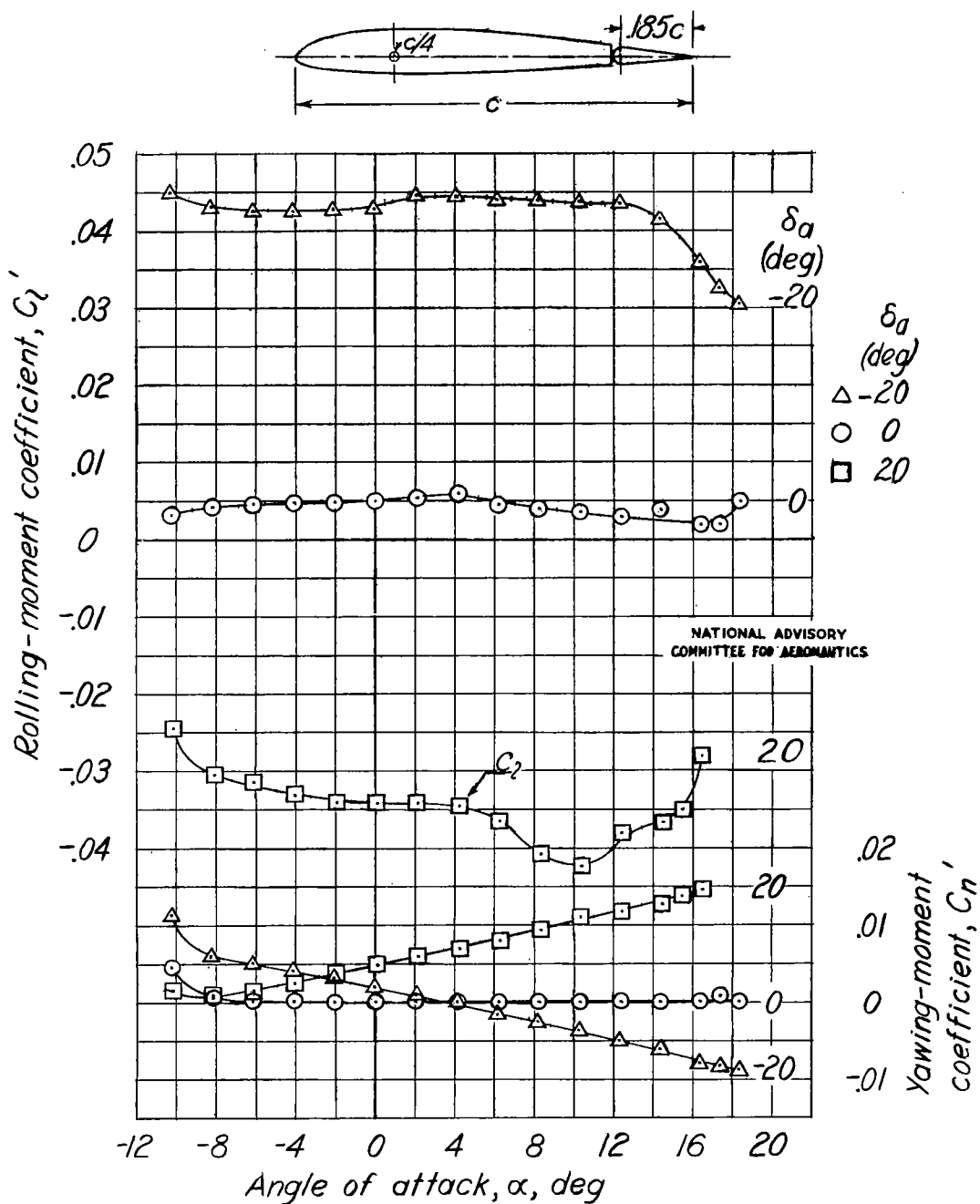
Figure 7.- Rolling-and yawing-moment characteristics of
the right semispan aileron on the NACA 2212 wing
model. No flaps.
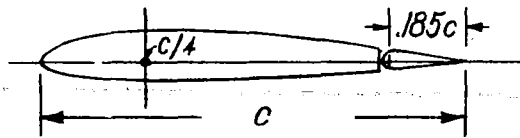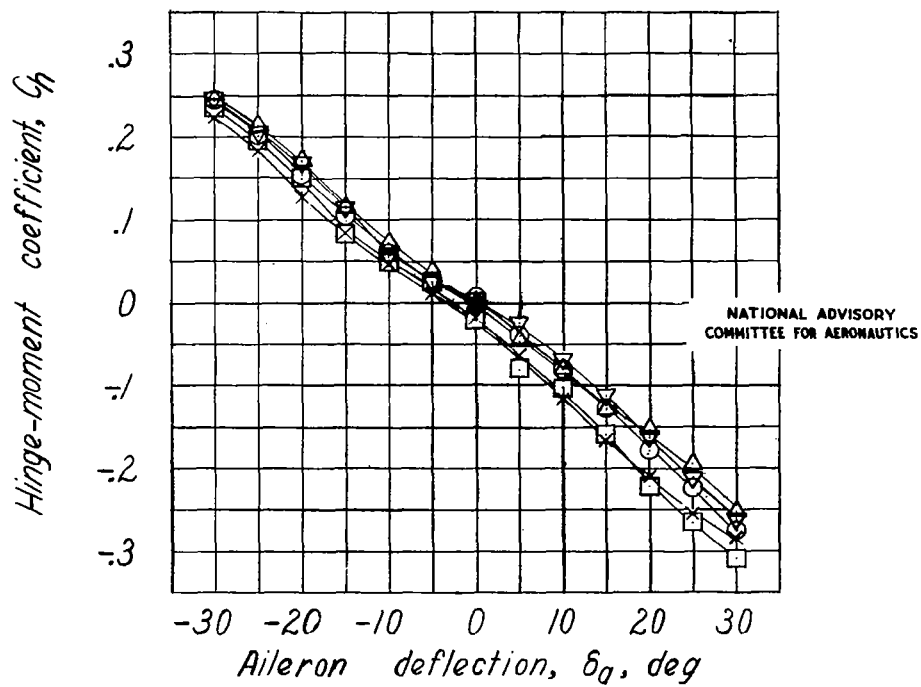
Figure 8.- Hinge-moment characteristics of the right semispan aileron on the NACA 2212 wing model. No flaps.

Fig. 9   NACA ARR No. L5B17
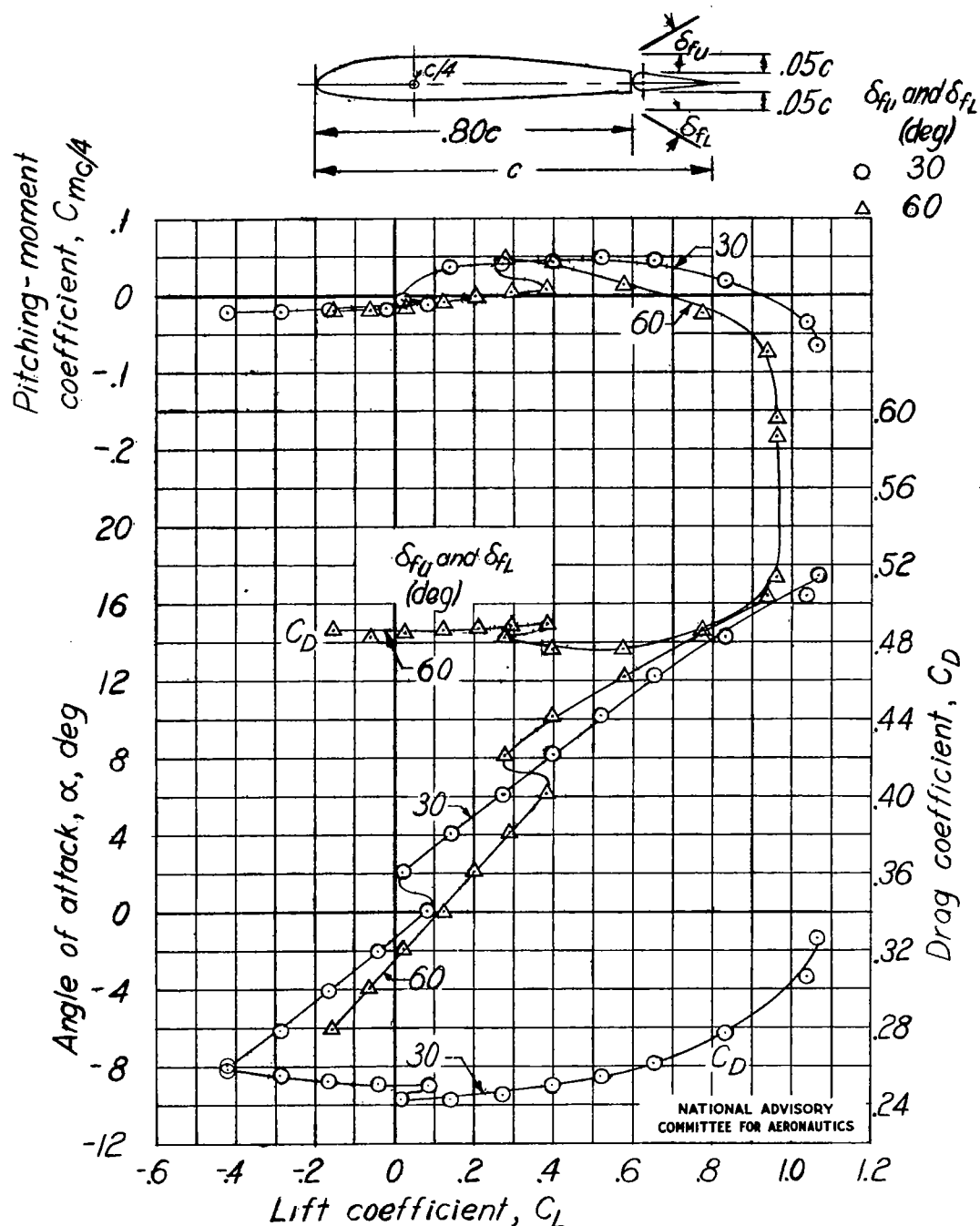
Figure.9.-Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Chordwise location, 0.80c; gaps, 0.05c; δ_a, 0°.
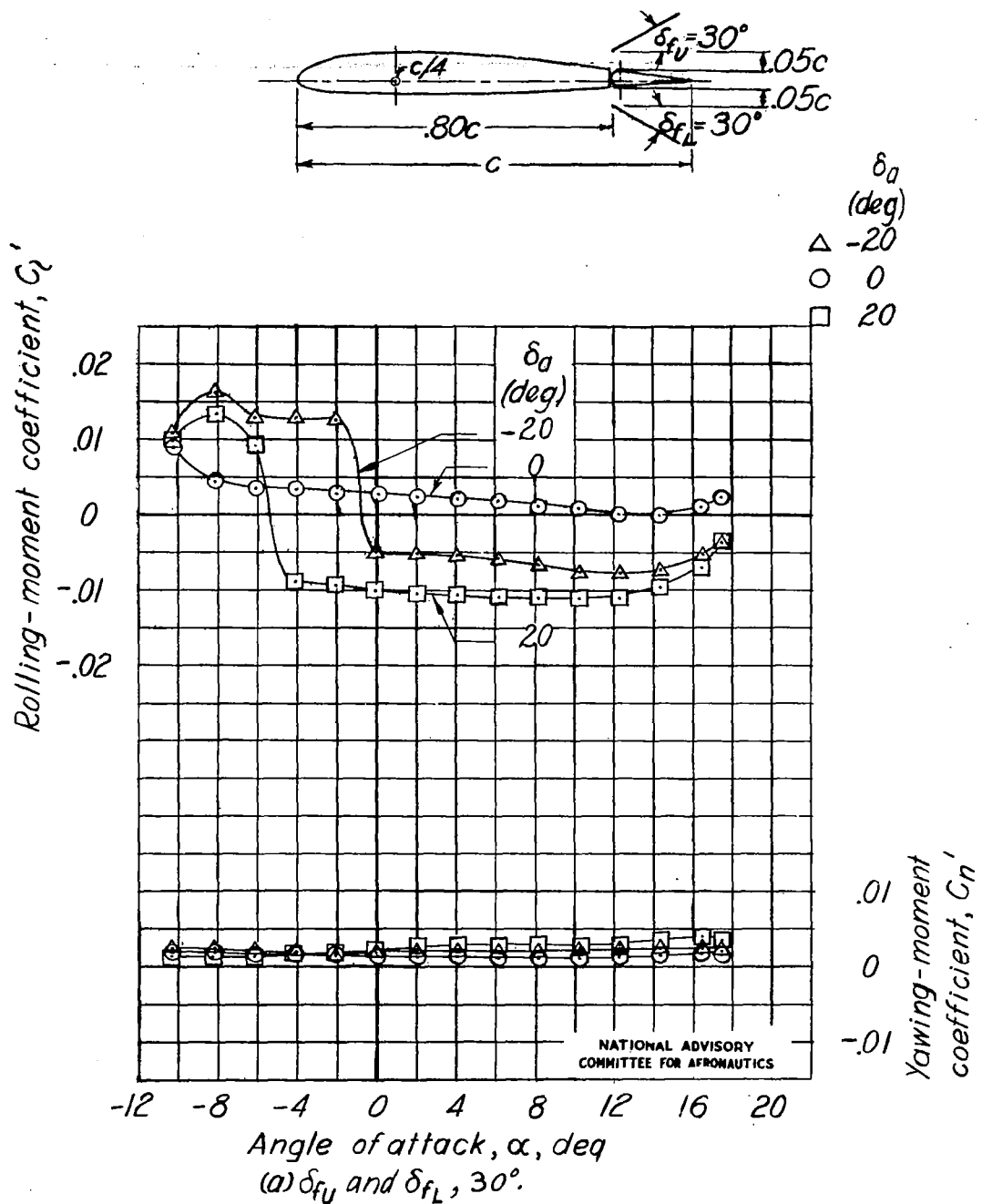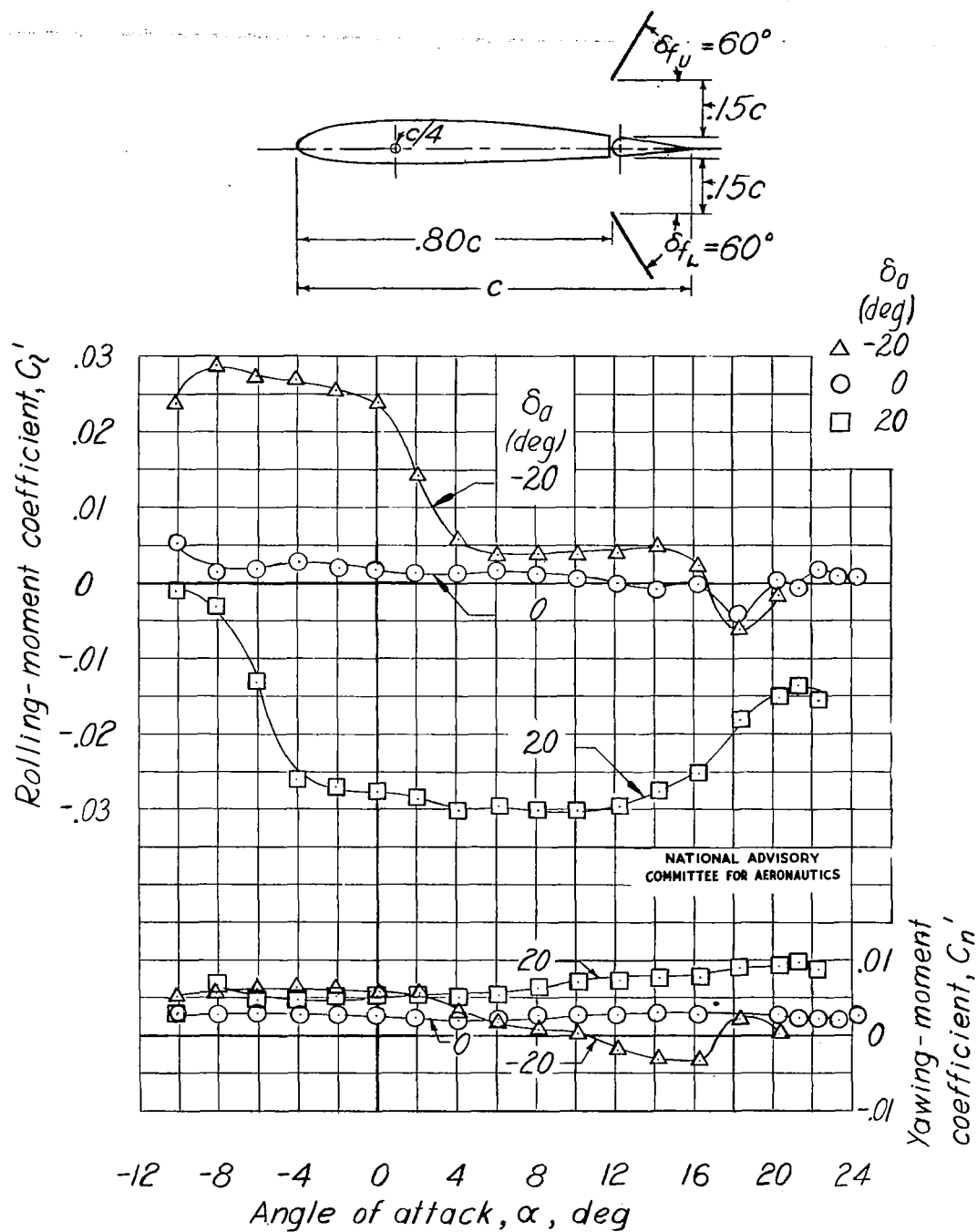
Figure 10.- Rolling-and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Chordwise location, 0.80c; gaps, 0.05c.

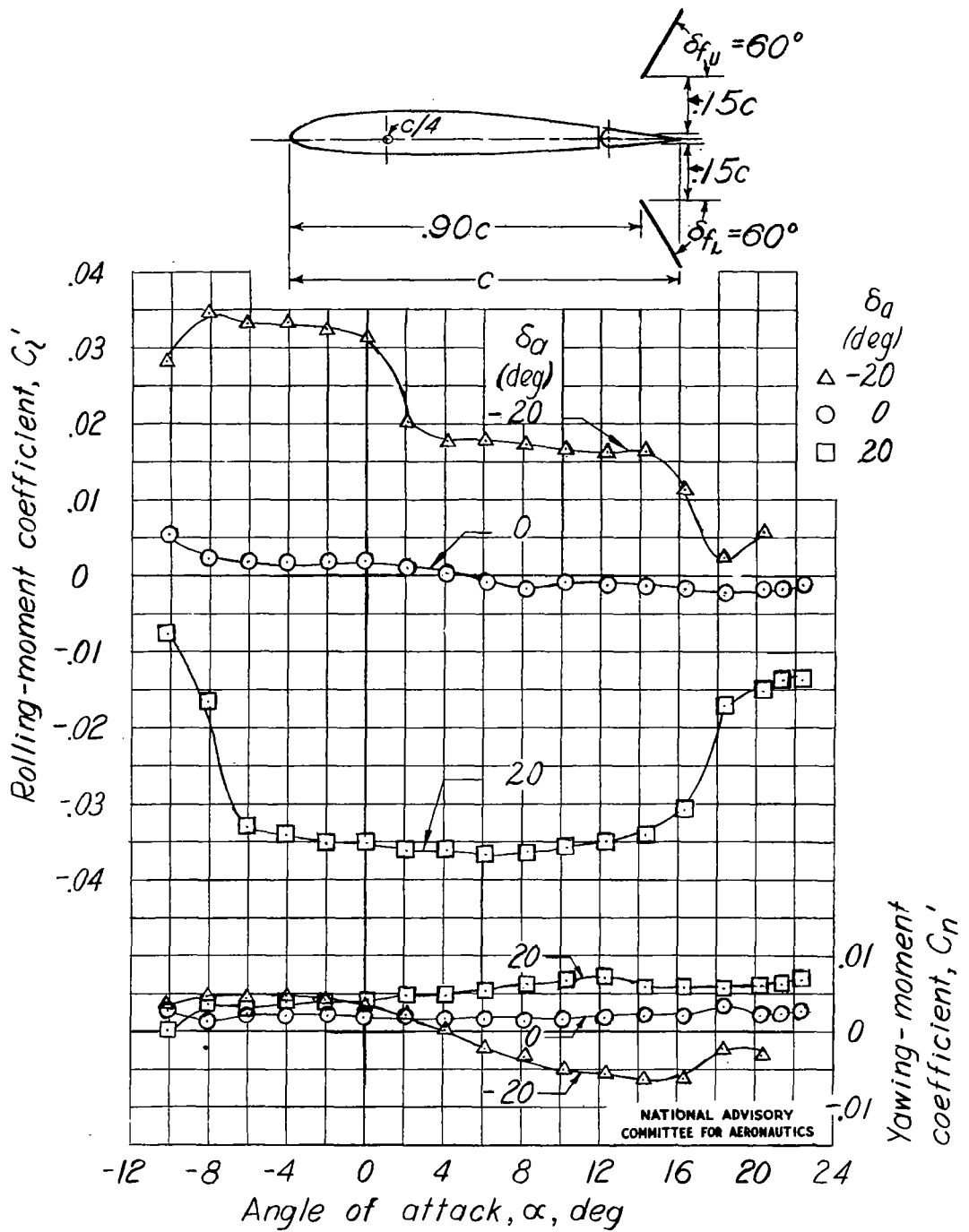(b) δ_{f_U} and δ_{f_L}, 60°.
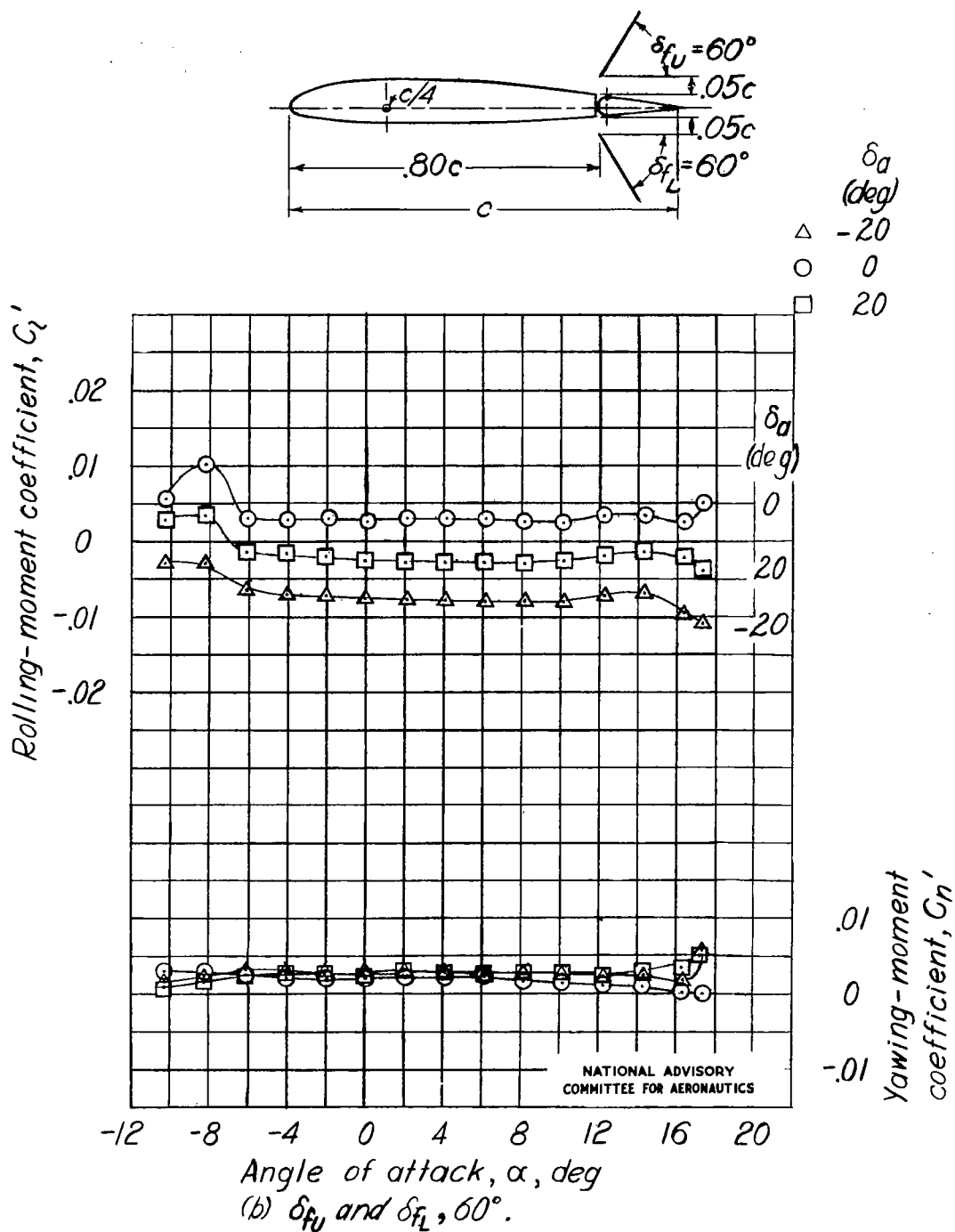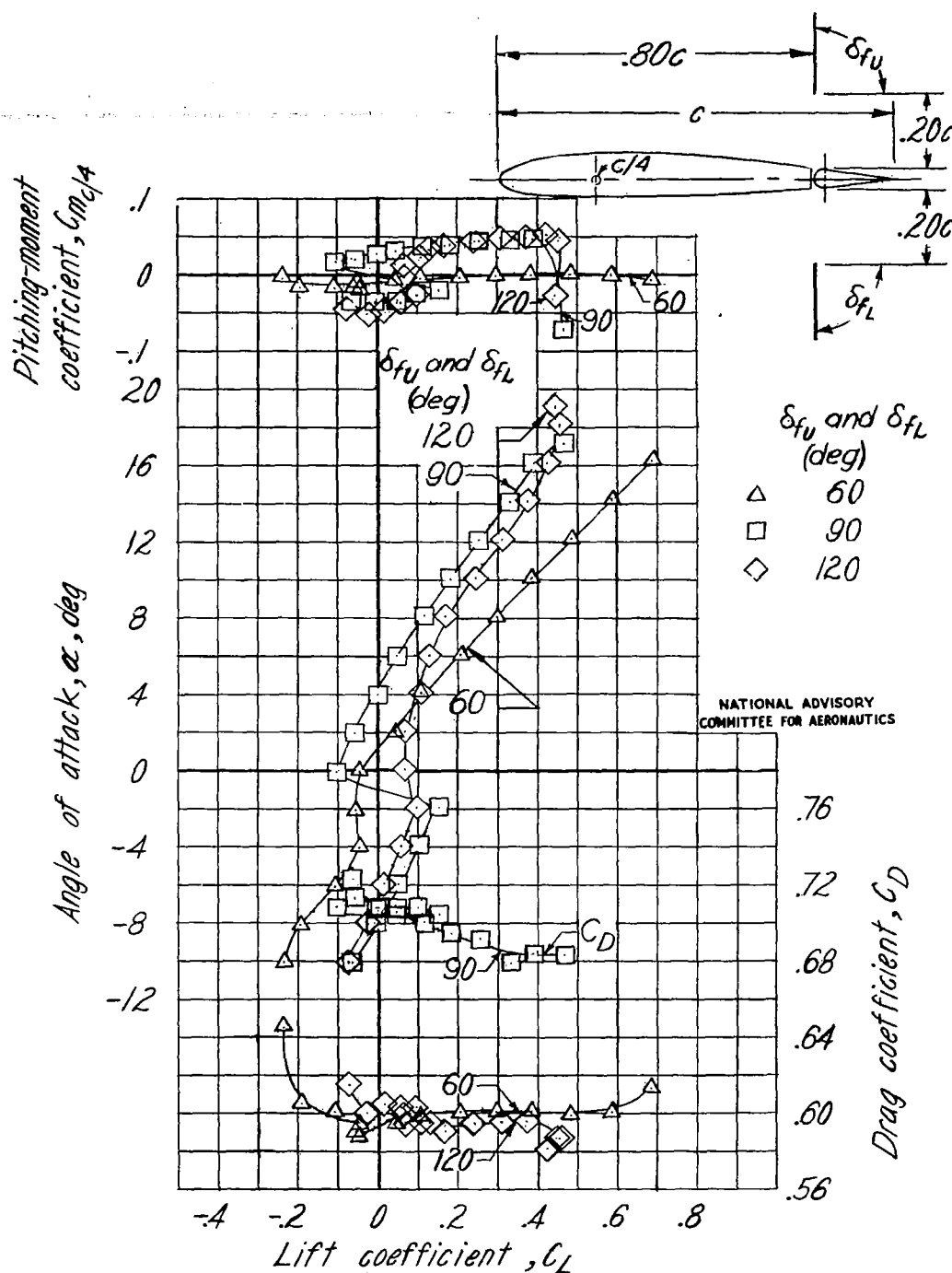
Figure 10.-Concluded.
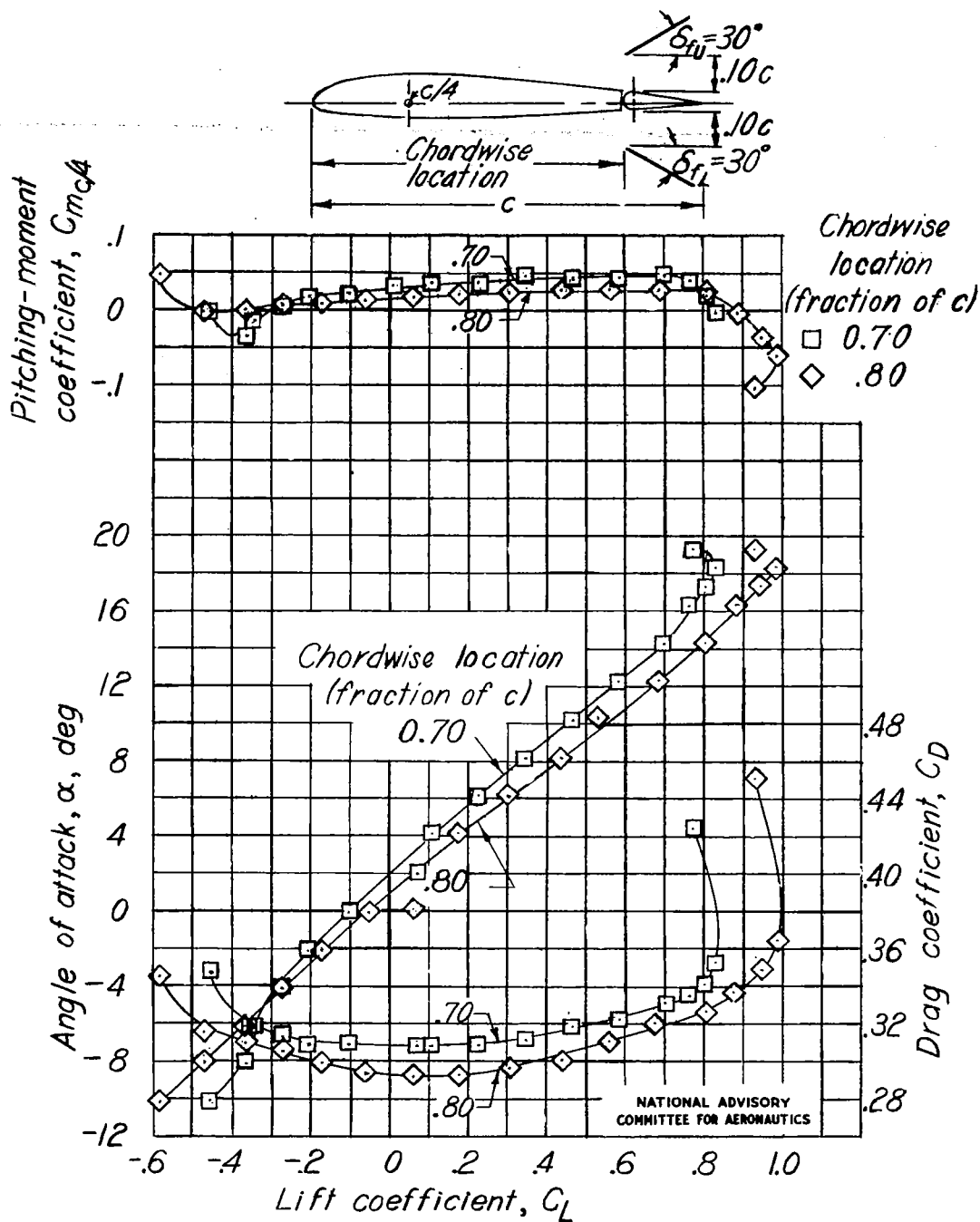
Figure 11.- Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Gaps, 0.10c; δ_a, 0°; δ_{f_U} and δ_{f_L}, 30°.
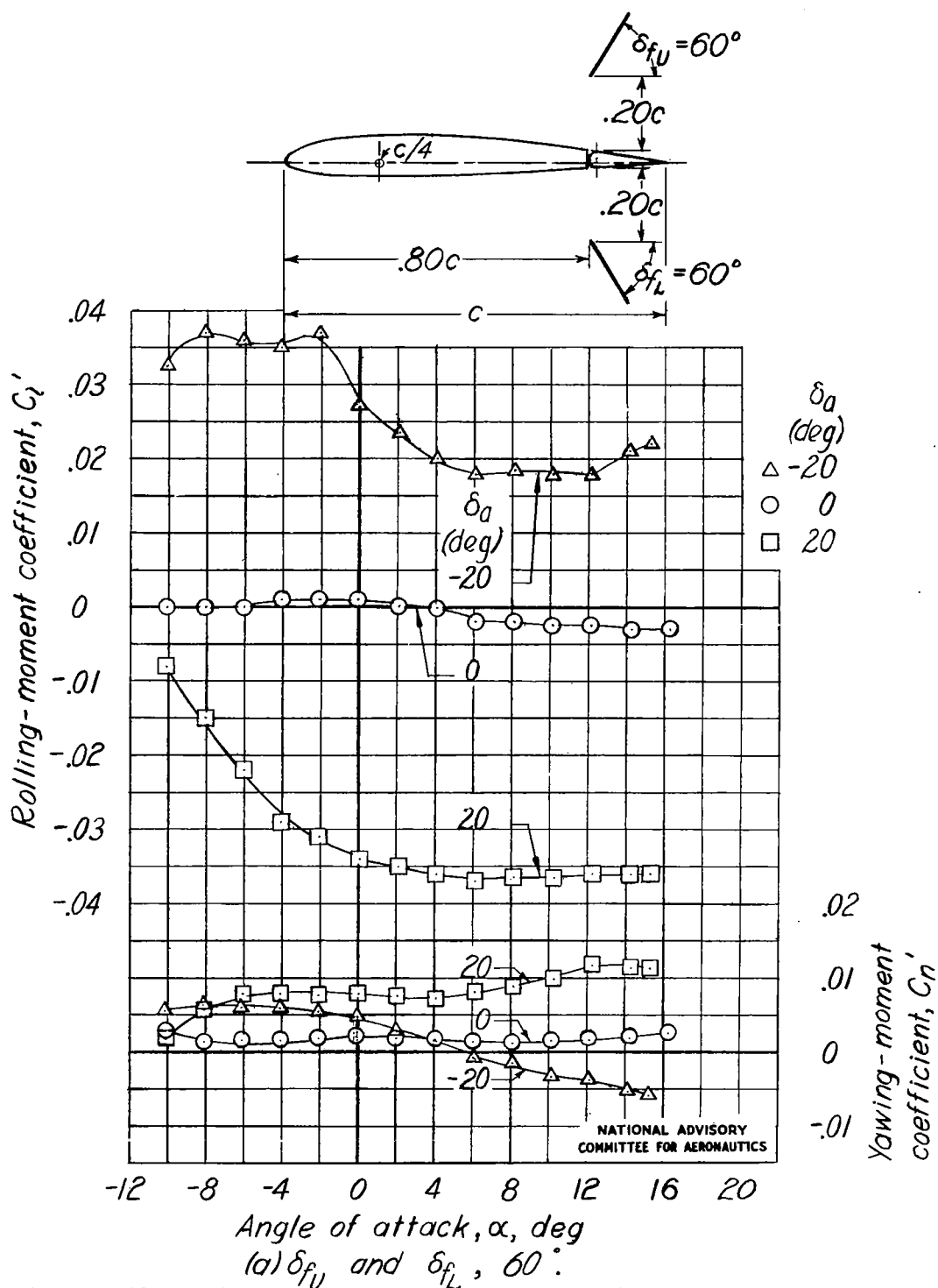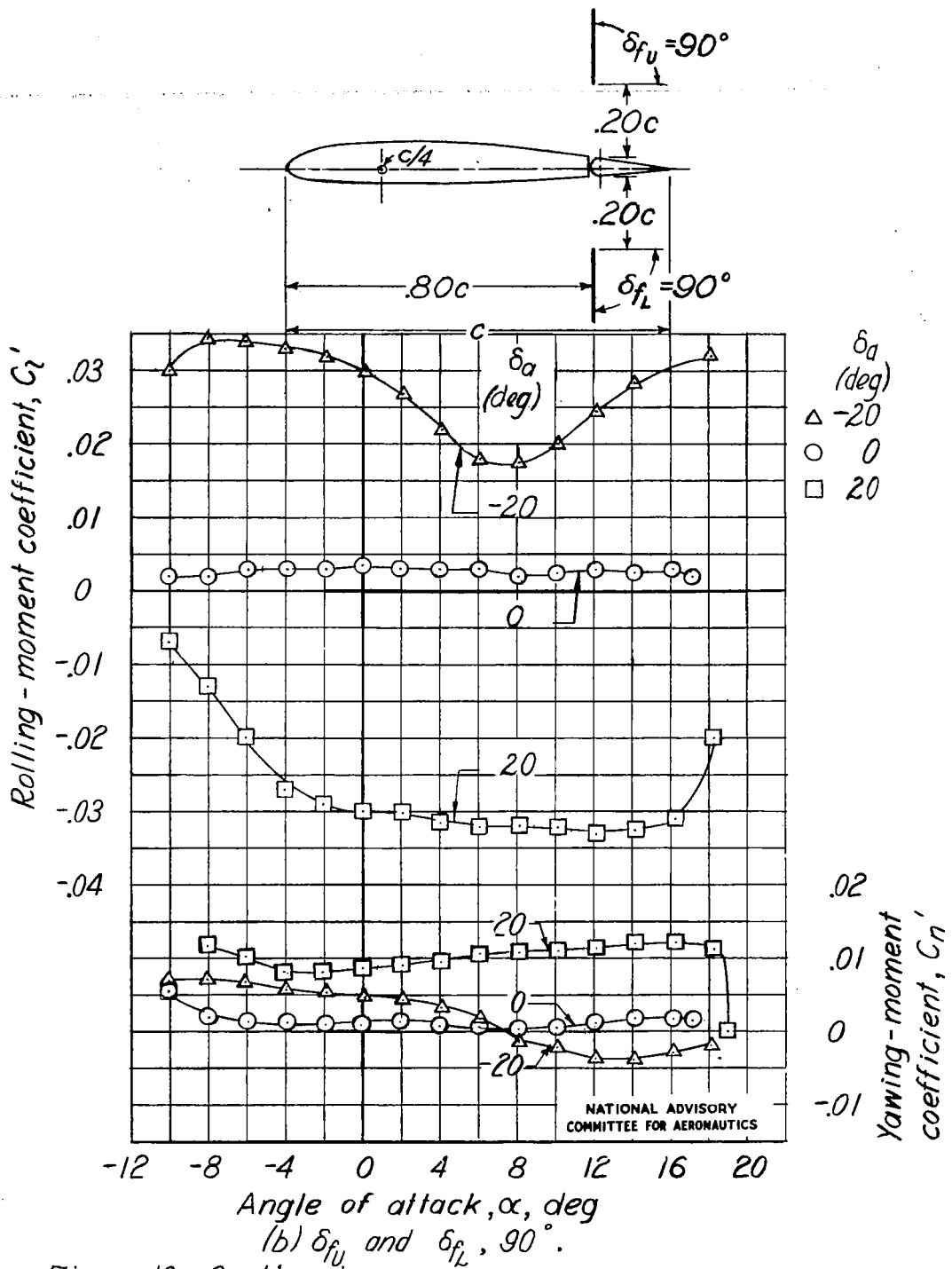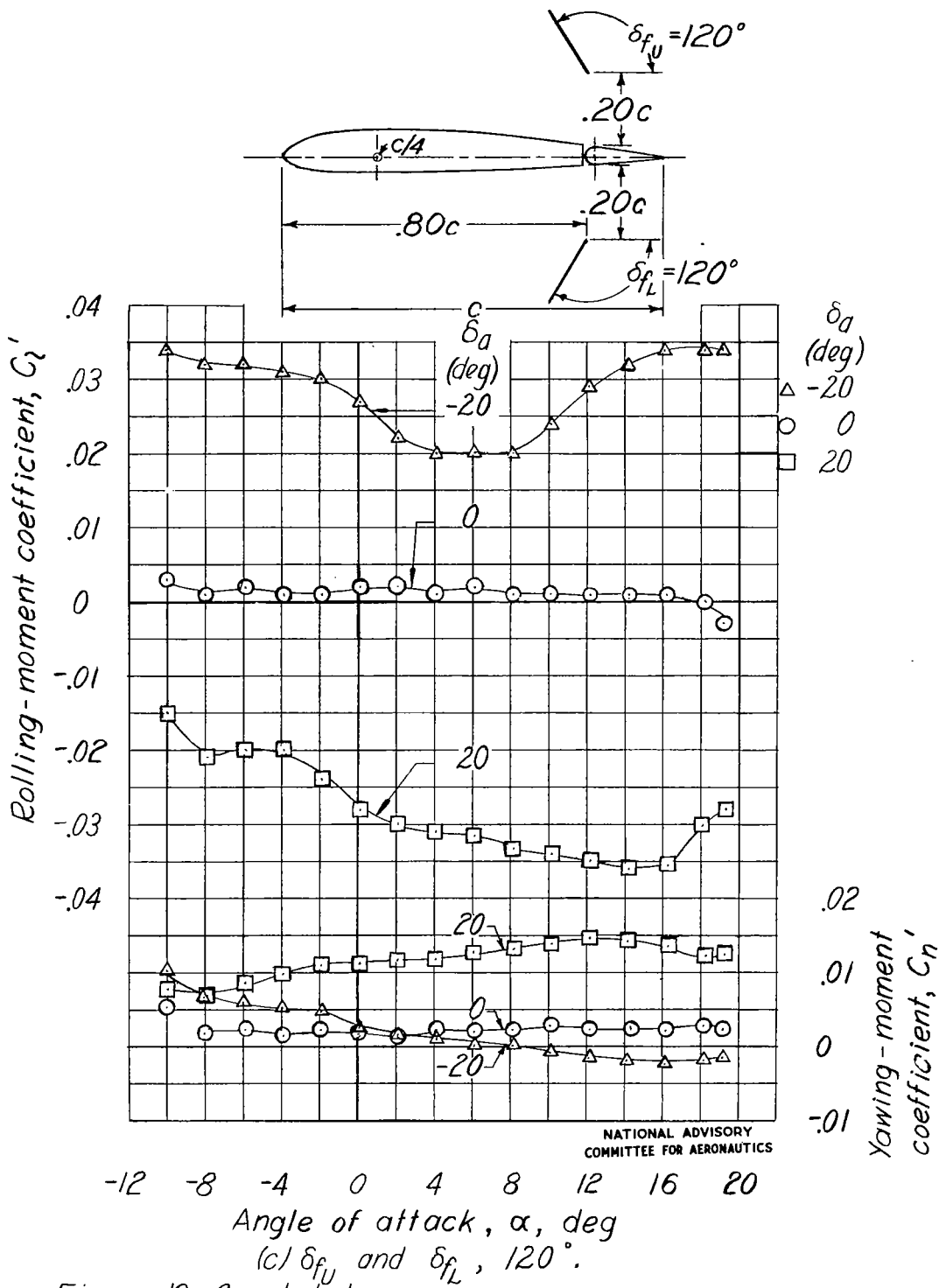
(a)Chordwise location, 0.70c.
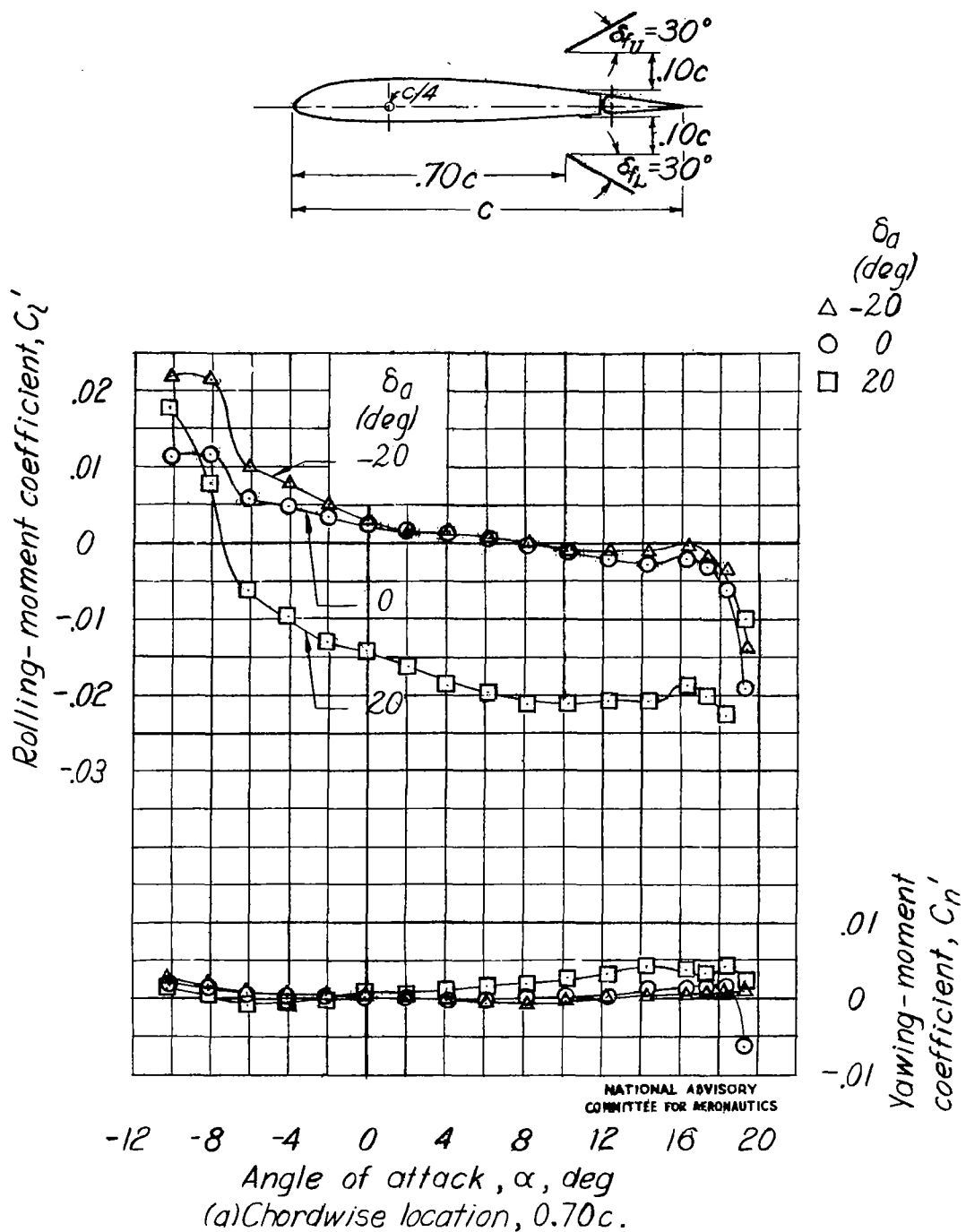
Figure 12.- Rolling-and yawing-moment characteristics of the right
semispan aileron on the NACA 2212 wing model equipped
with balanced double split flaps having flat-plate sections.
Gaps, 0.10c; δ_{f_U} and δ_{f_L}, 30°.
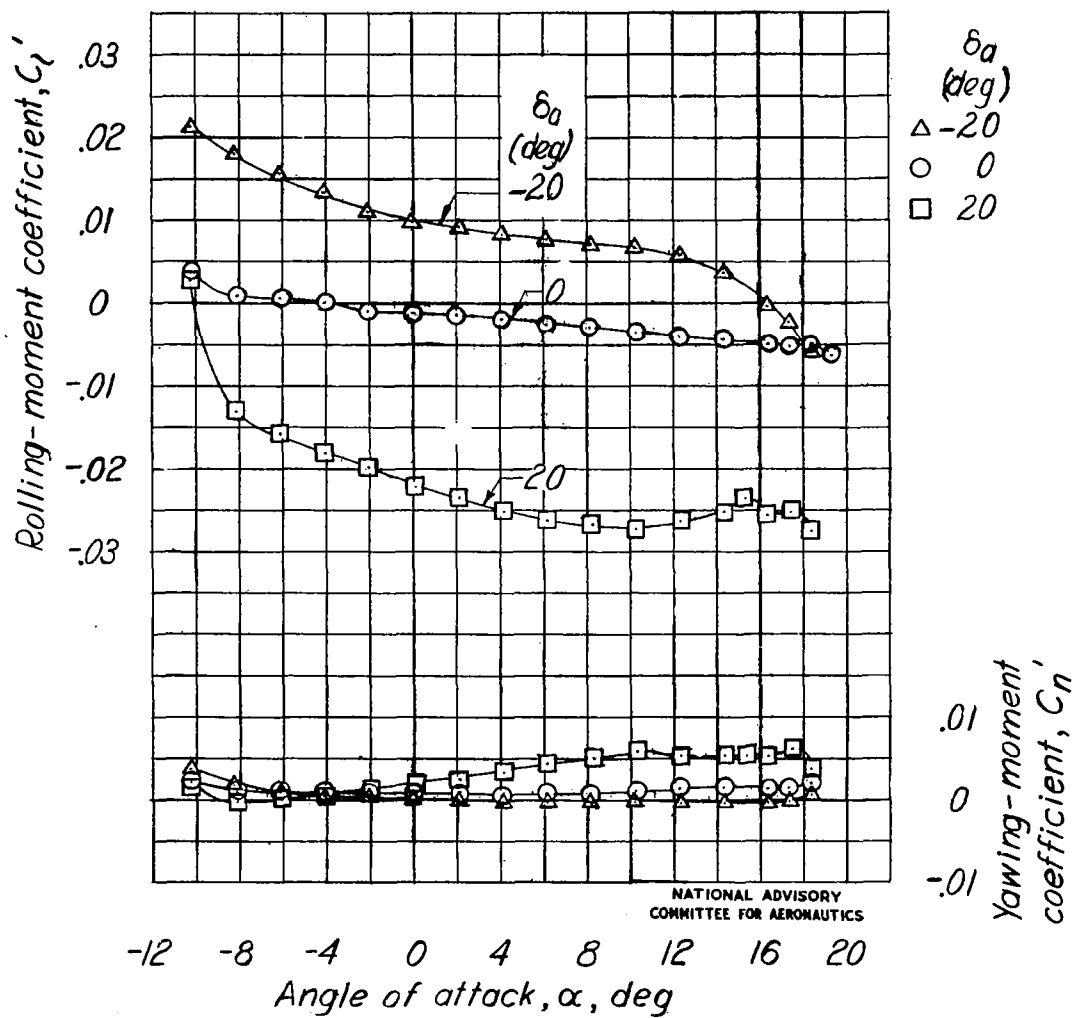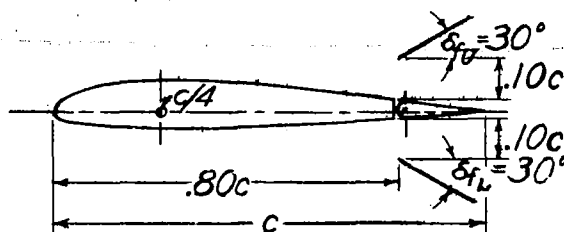
(b) Chordwise location, 0.80c.

Figure 12.- Concluded.

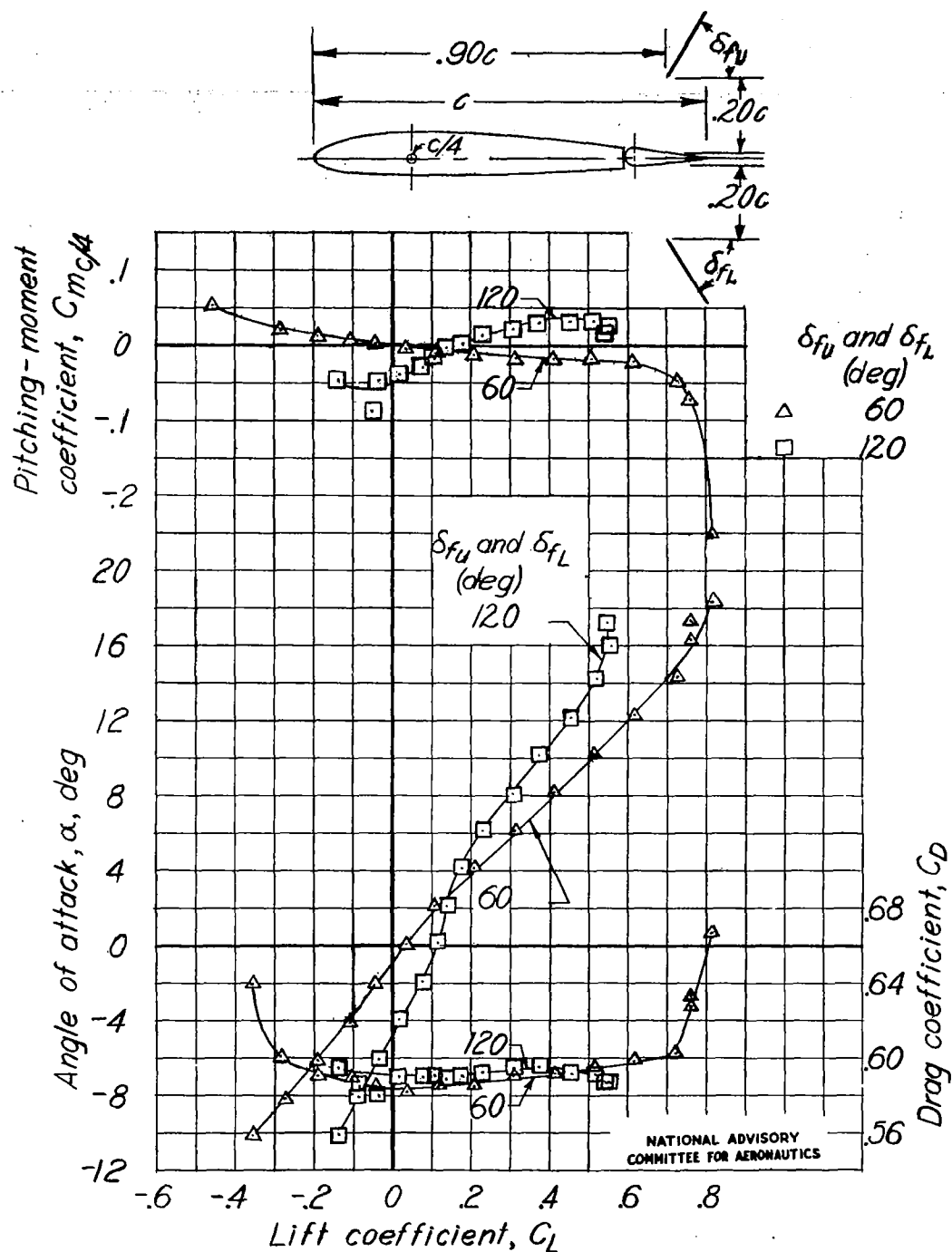Fig. 13   NACA ARR No. L5B17
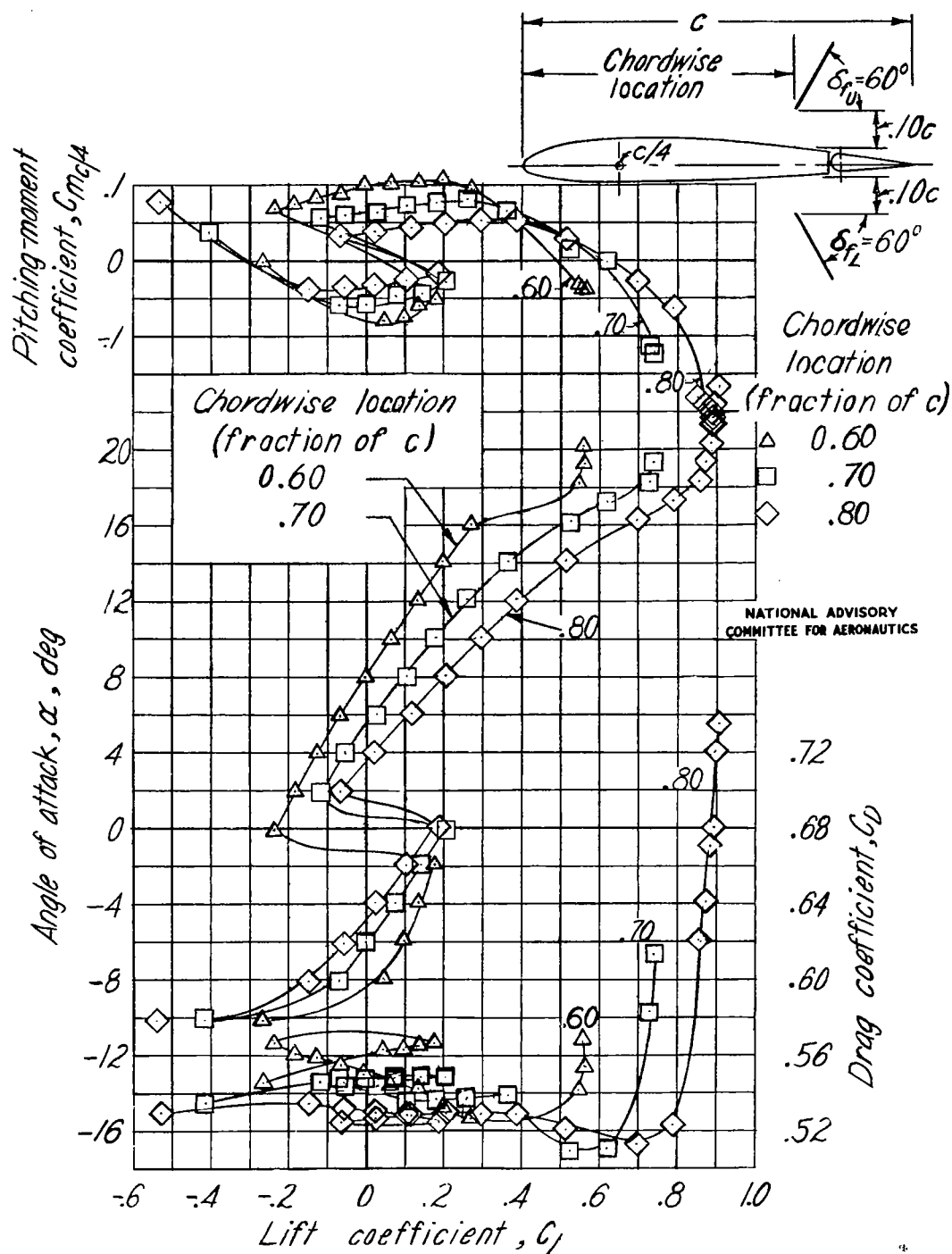
Figure 13.- Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Gaps, 0.10c; δ_a, 0°; δ_{f_U} and δ_{f_L}, 60°.
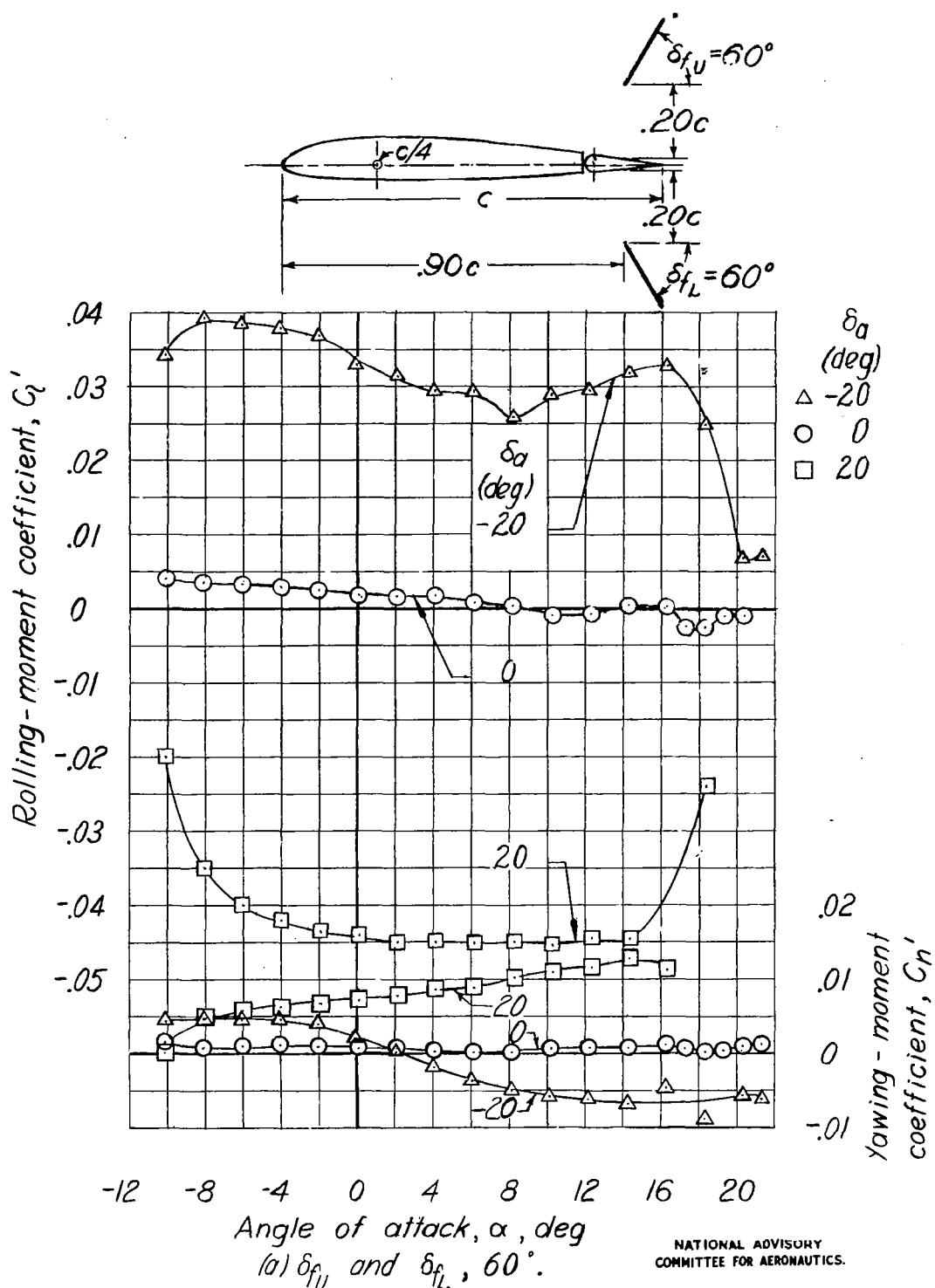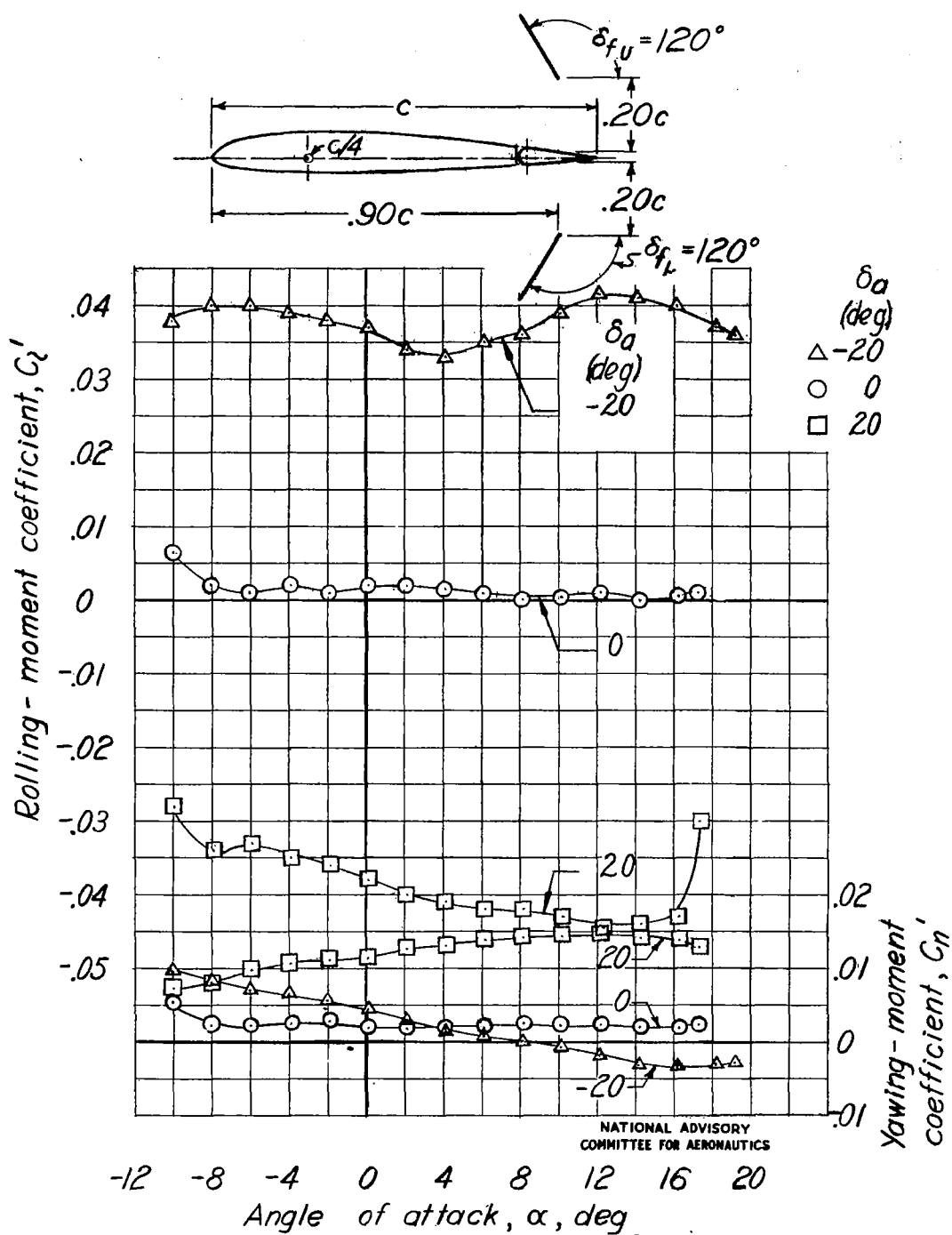
(a) Chordwise location, 0.60c.
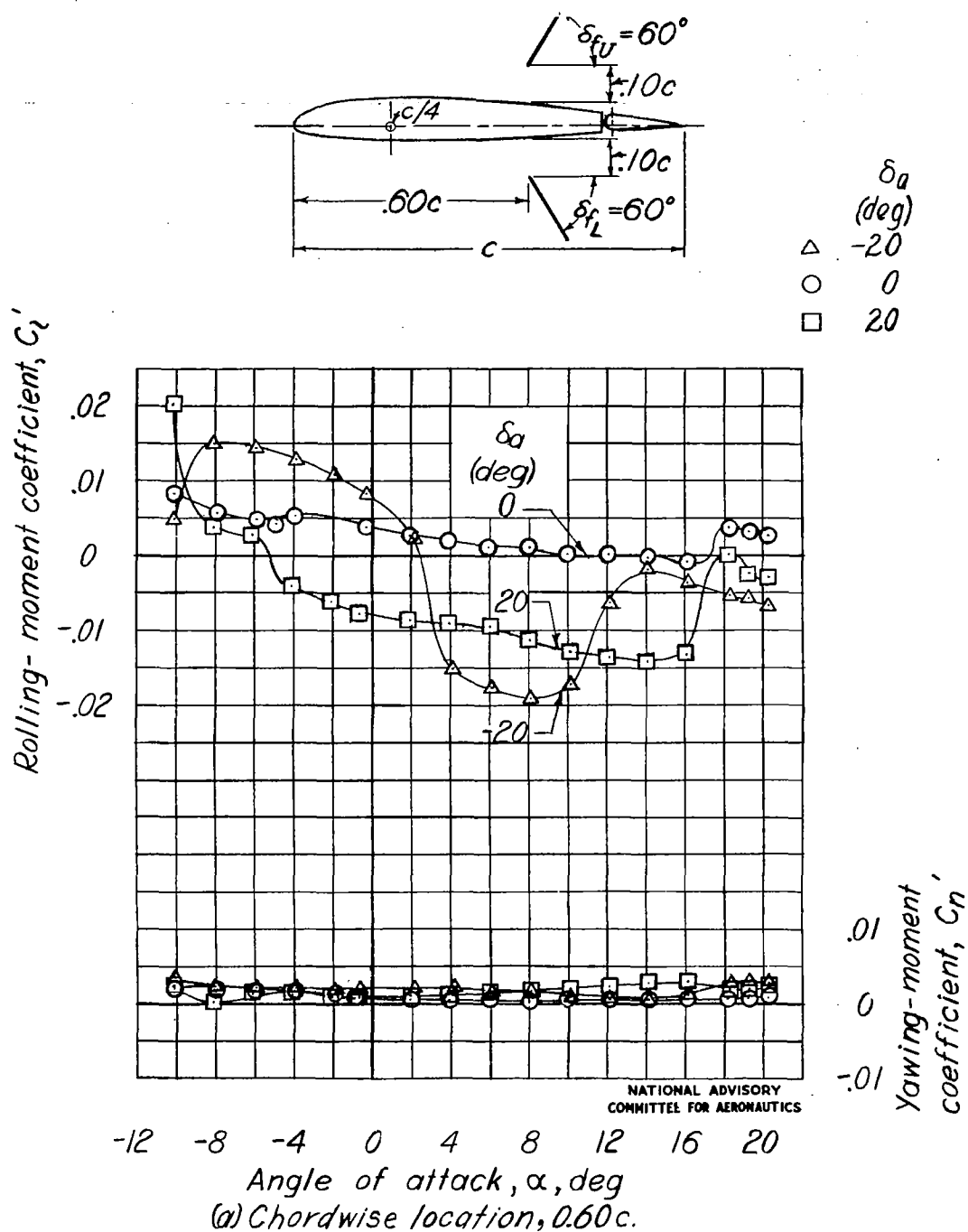
Figure 14.—Rolling-and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Gaps, 0.10c; δ_{f_U} and δ_{f_L}, 60°.
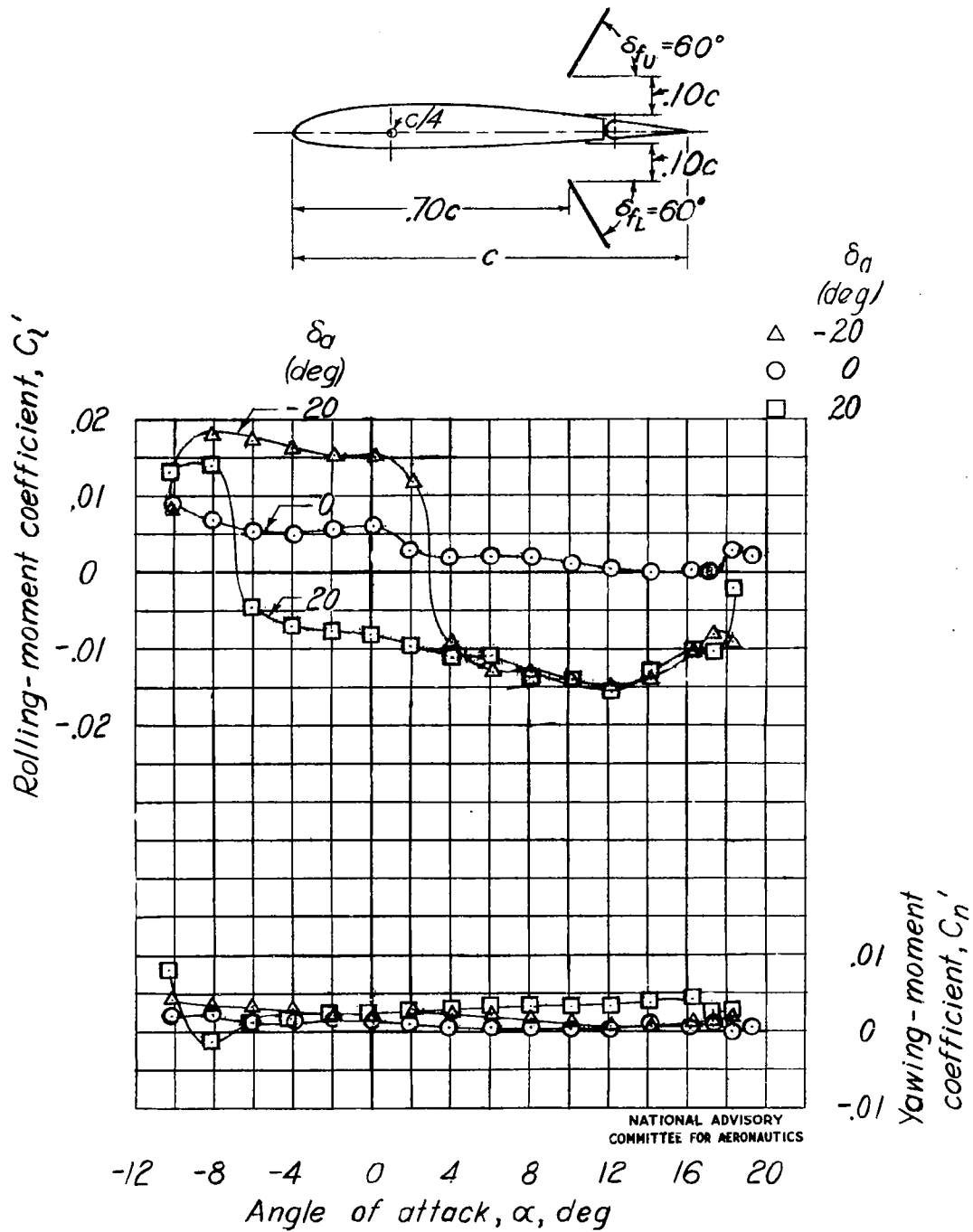
(b) Chordwise location, 0.70c.

Figure 14.-Continued.

$\delta_{f_U} = 60°$

$.10c$

$c/4$

$.10c$

$\delta_{f_L} = 60°$

$.80c$

c

Rolling-moment coefficient, $C_l{}'$

δ_a (deg)

.02

.01

0

-.01

-.02

δ_a (deg)

-20

-10

0

10

20

	δ_a (deg)
△	-20
×	-10
○	0
◇	10
□	20

.01

0

-.01

Yawing-moment coefficient, $C_n{}'$

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

-12   -8   -4   0   4   8   12   16   20   24

Angle of attack, α, deg

(c) Chordwise location, 0.80c.
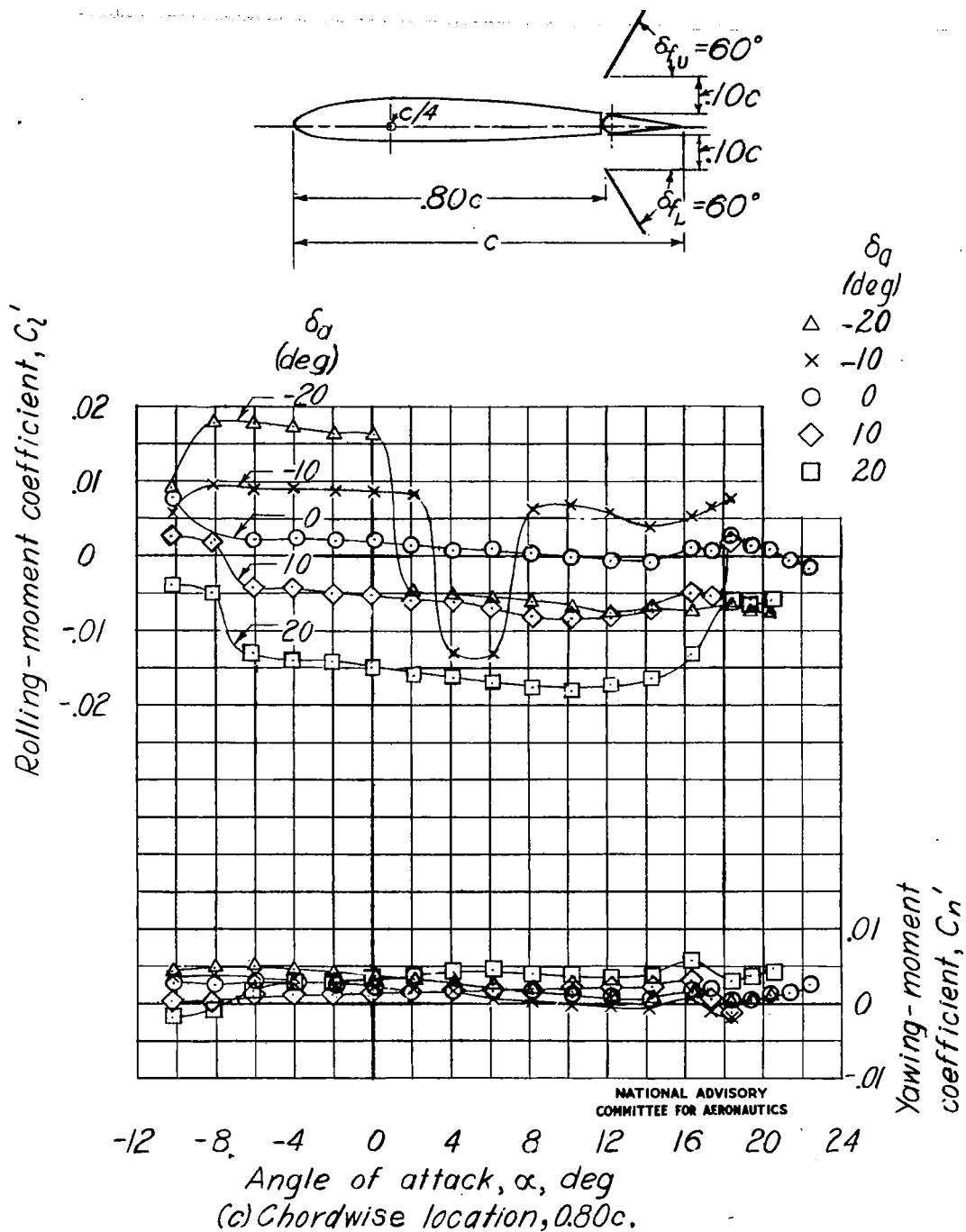
Figure 14.- Concluded.

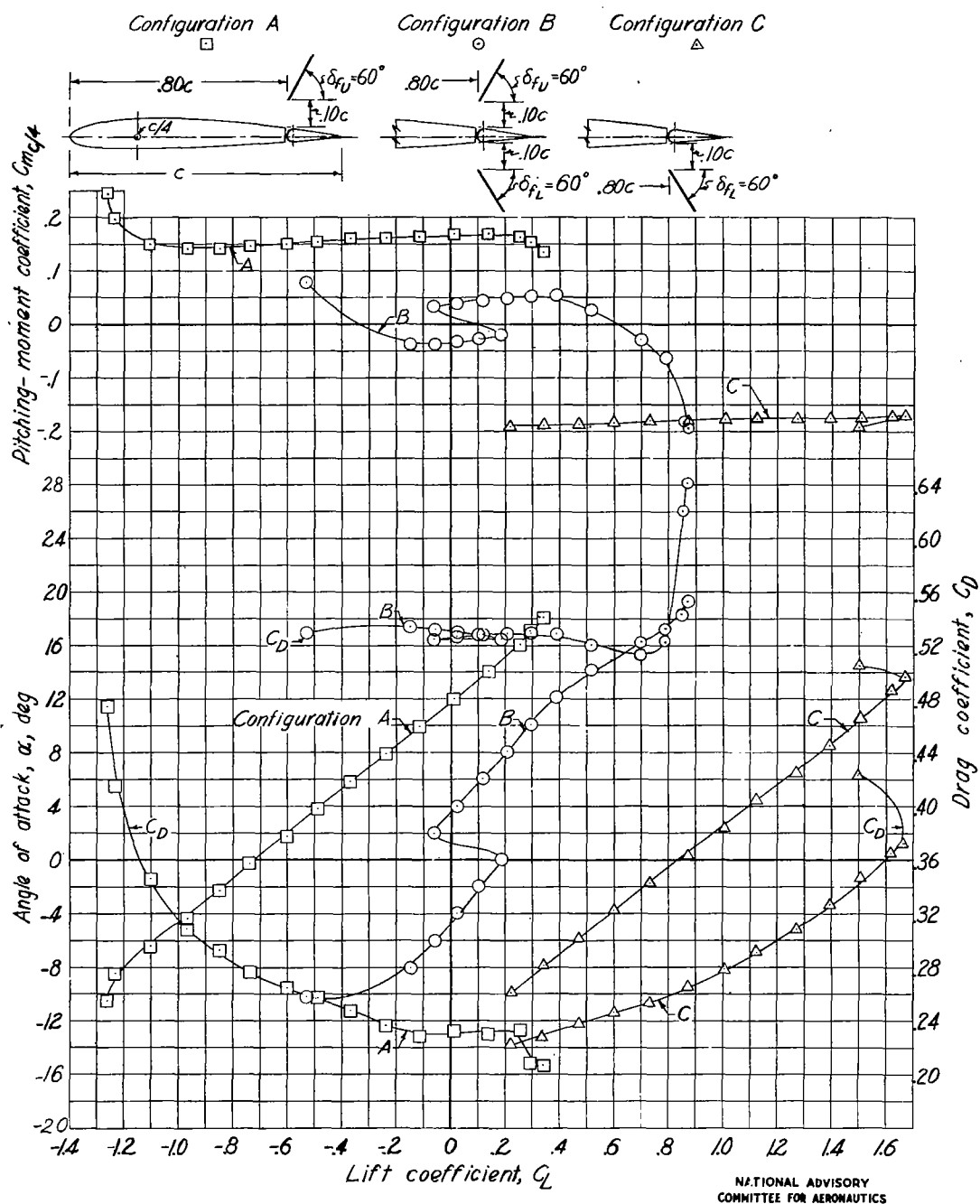Fig. 15   NACA ARR No. L5B17
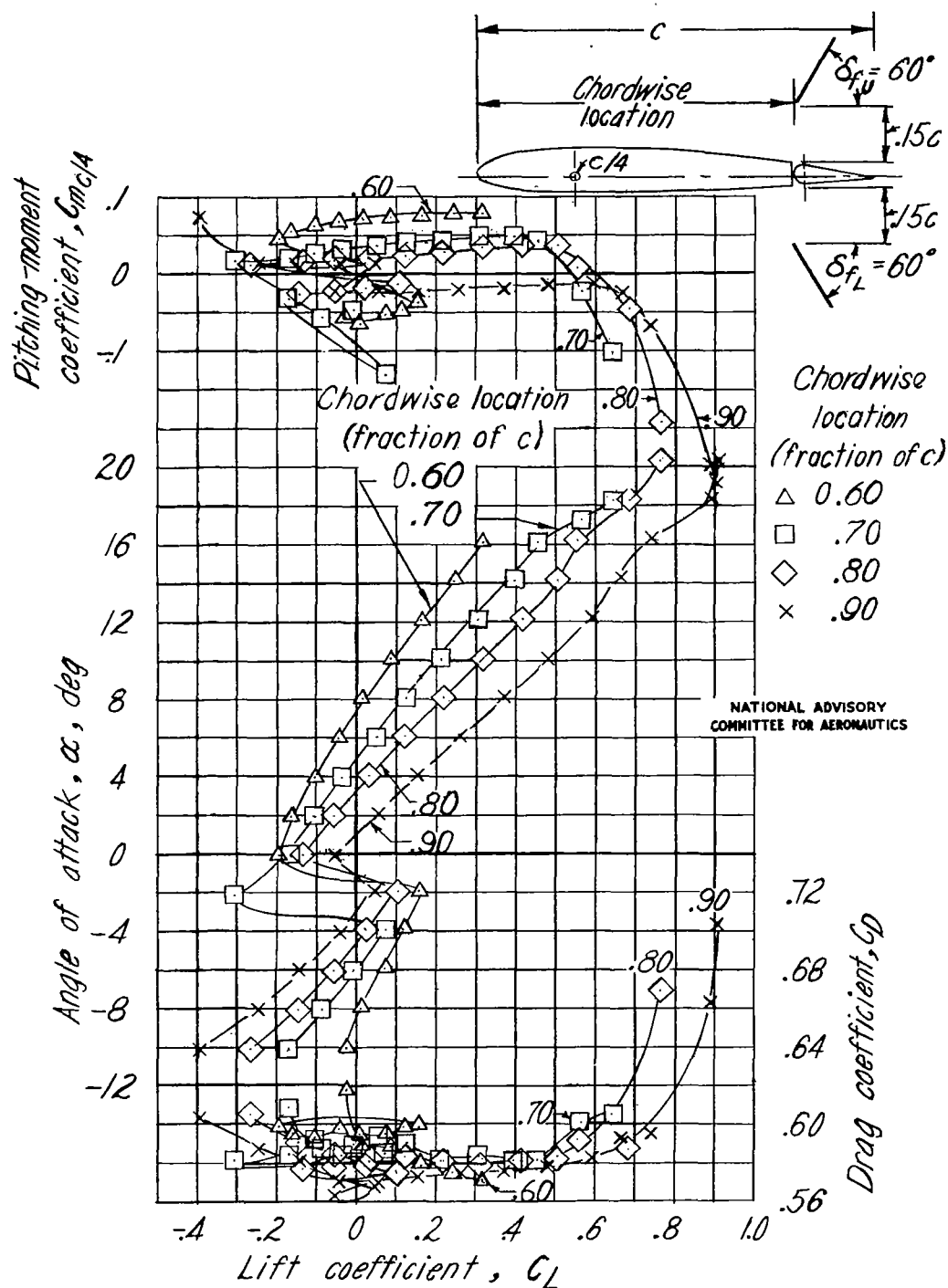
Figure 15.- Lift, drag, and pitching-moment characteristics
   of the NACA 2212 wing model equipped with balanced double
   split flaps having flat-plate sections. Gaps, 0.15c; δ_a, 0°;
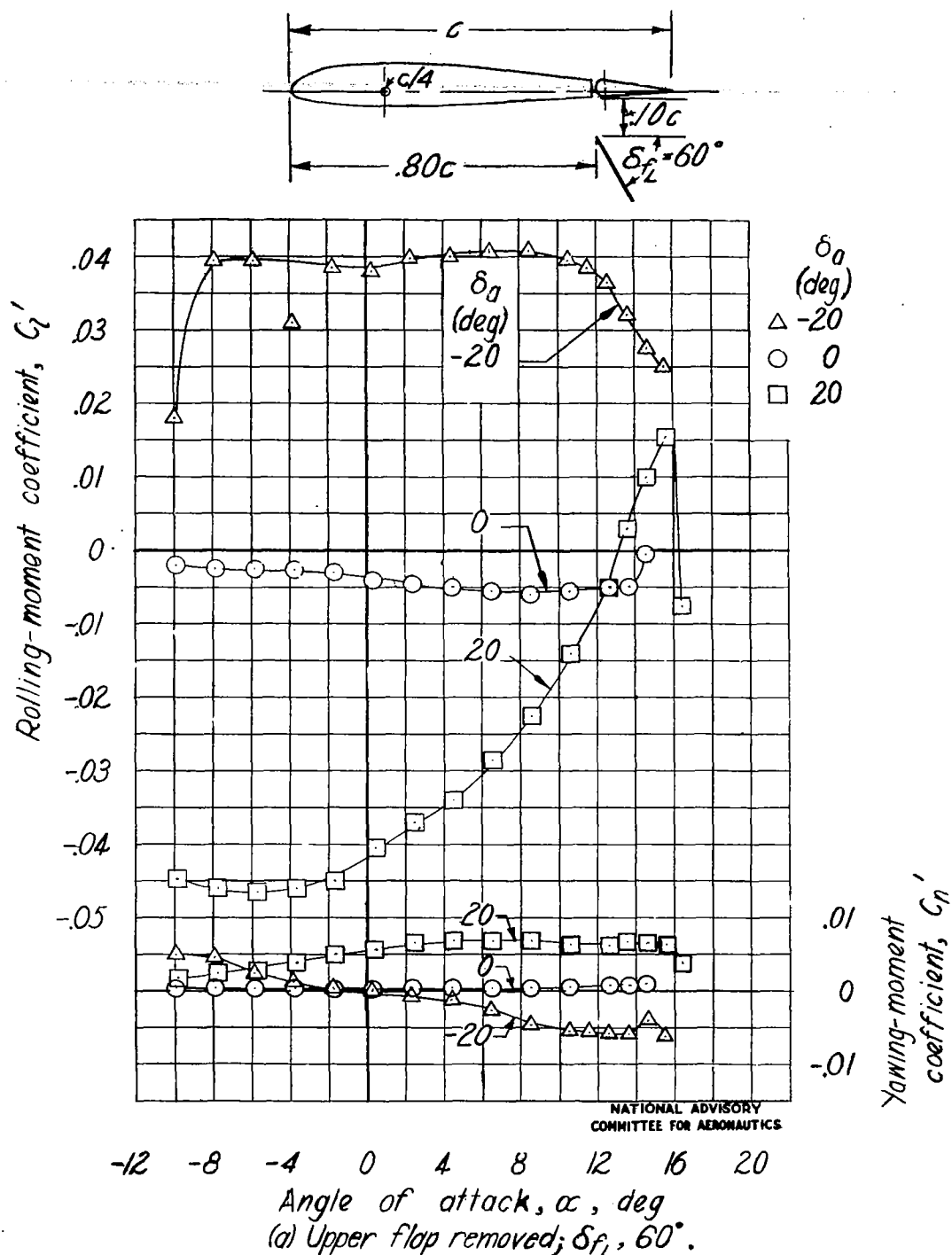 δ_{f_U} and δ_{f_L}, 60°.
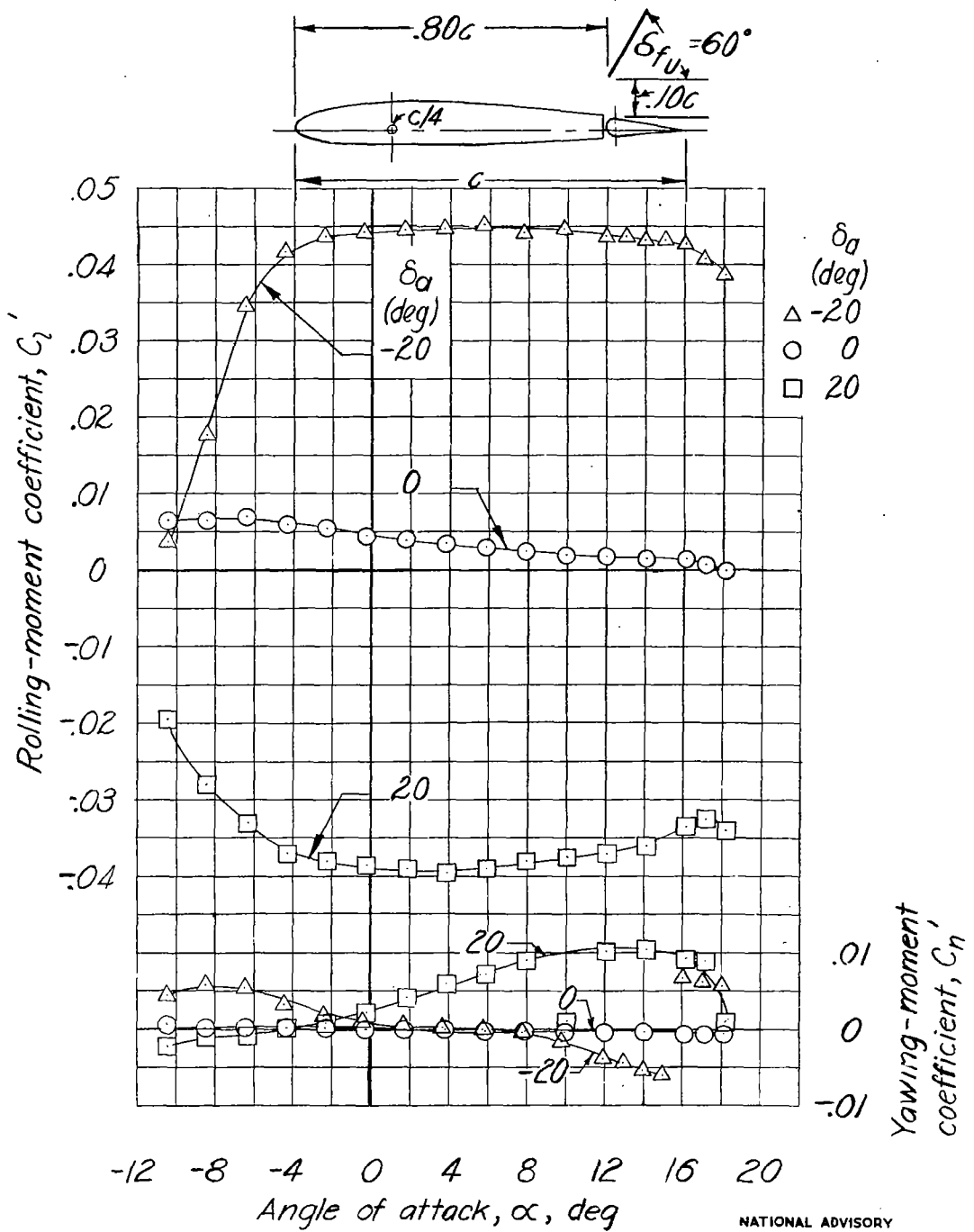
(a) Chordwise location, 0.60c.
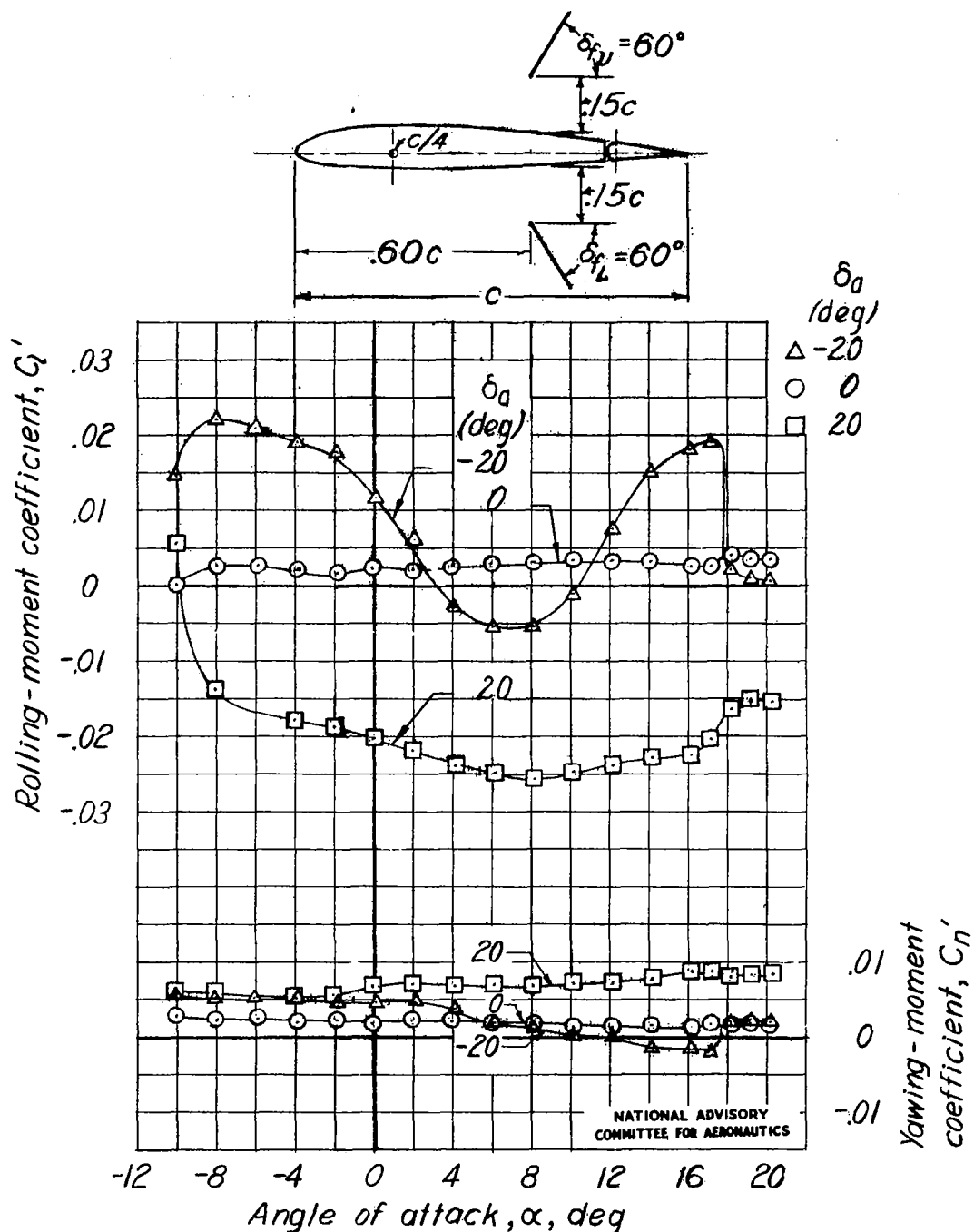
Figure 16.— Rolling- and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Gaps, 0.15c; δ_{f_U} and δ_{f_L}, 60°.
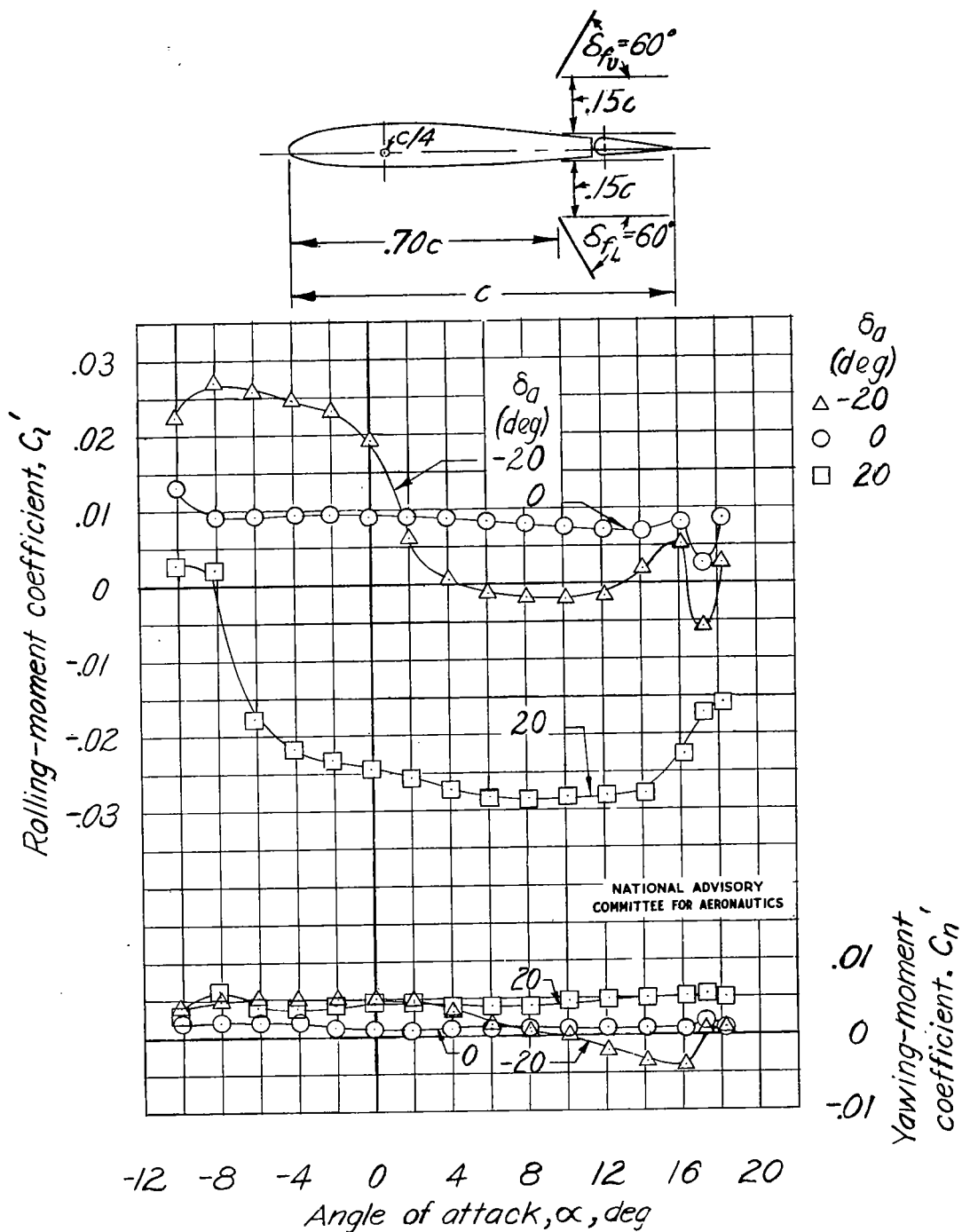
(b) Chordwise location, 0.70c.

Figure 16.- Continued.

(c) Chordwise location, 0.80c.

Figure 16.- Continued.

(d) Chordwise location, 0.90c.

Figure 16.—Concluded.

Figure 17.- Lift, drag, and pitching-moment characteristics of
the NACA 2212 wing model equipped with balanced
double split flaps having flat-plate sections.
Chordwise location, 0.80c; gaps, 0.20c; δ_a, 0°.

(a) δ_{f_U} and δ_{f_L}, 60°.

Figure 18.— Rolling- and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Chordwise location, 0.80c; gaps, 0.20c.
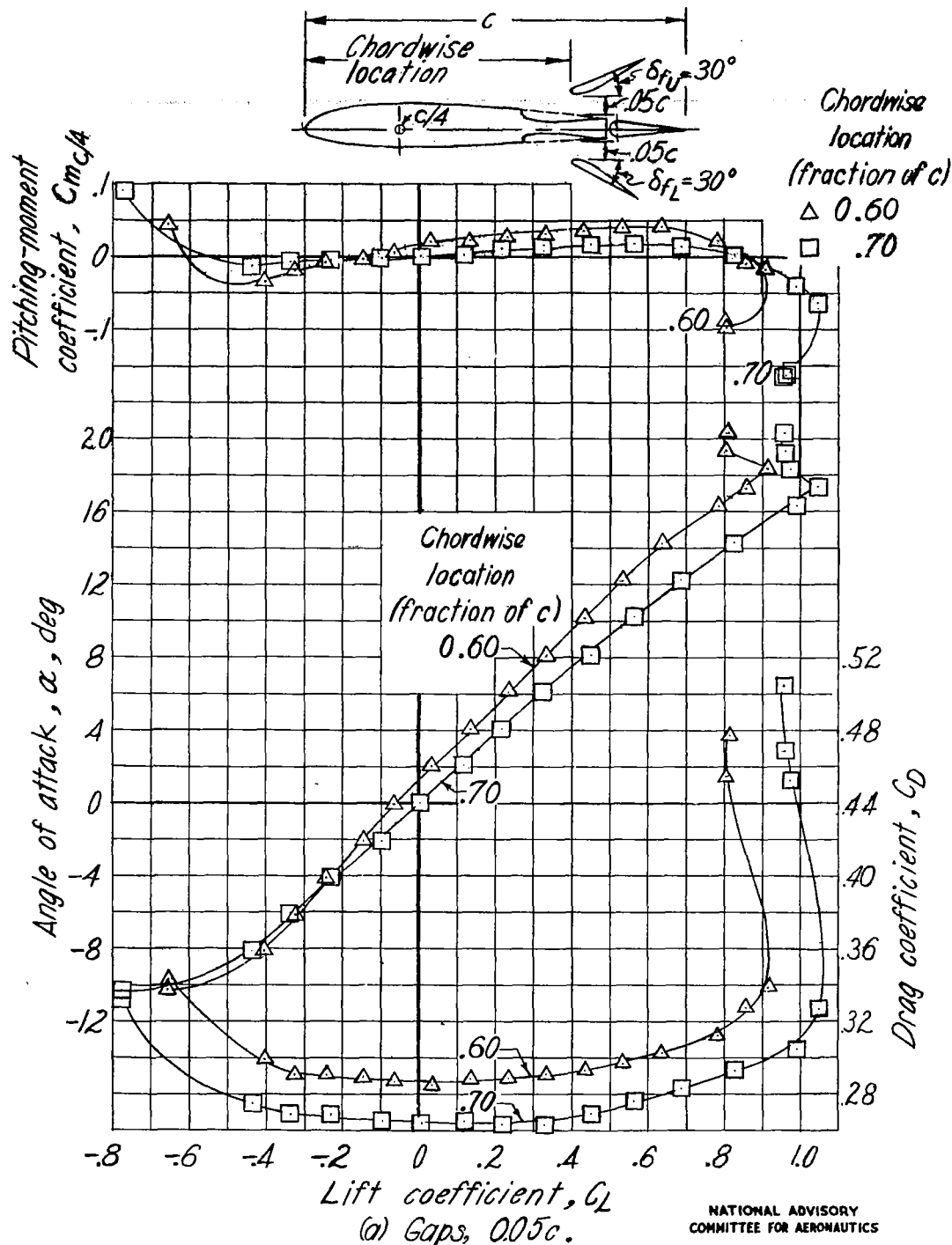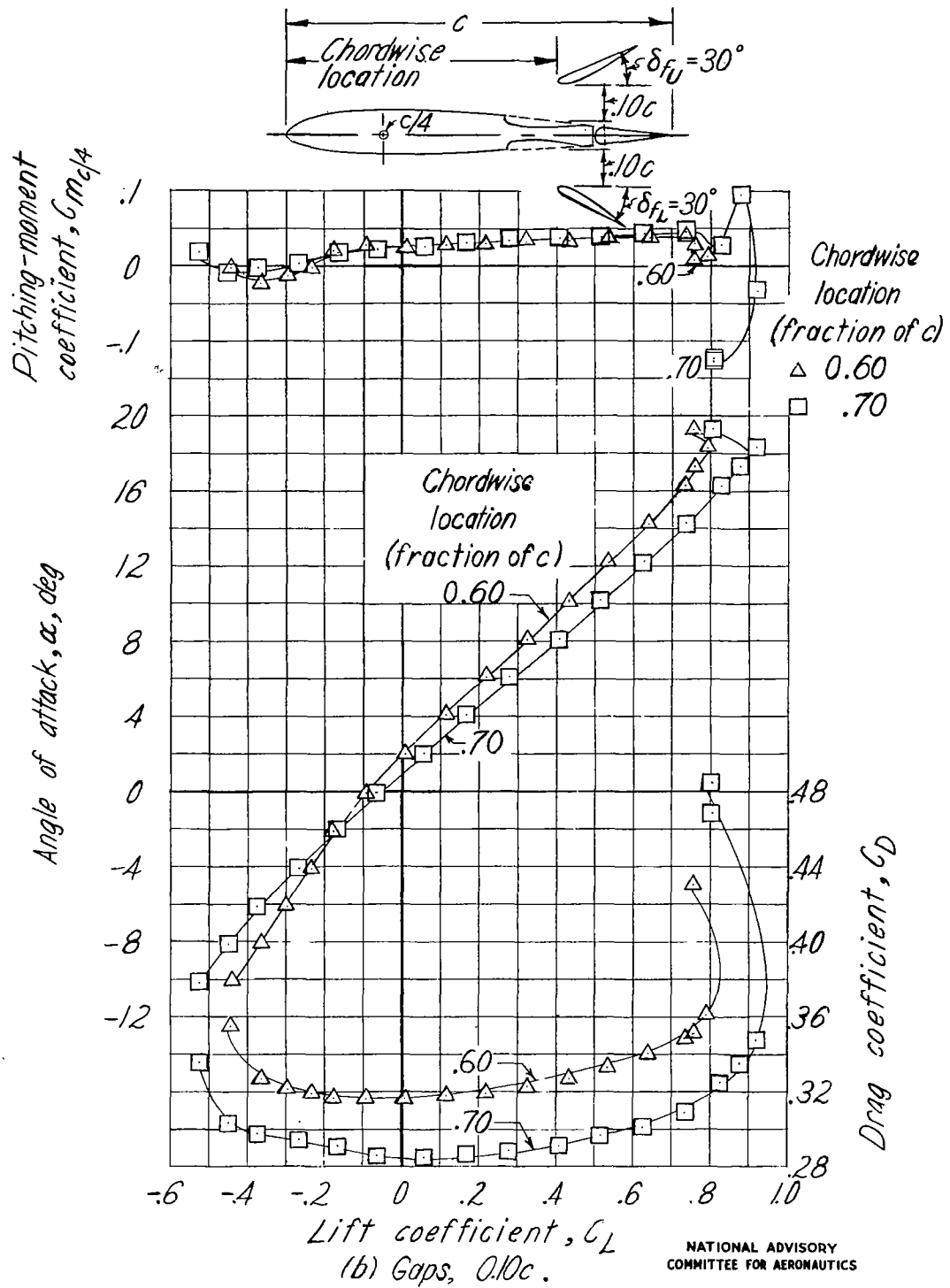
(b) δ_{f_u} and δ_{f_L}, 90°.

Figure 18.- Continued.

(c) δ_{f_U} and δ_{f_L}, 120°.

Figure 18.- Concluded.

Figure 19.–Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Chordwise location, 0.90c; gaps, 0.20c; δ_a, 0.°
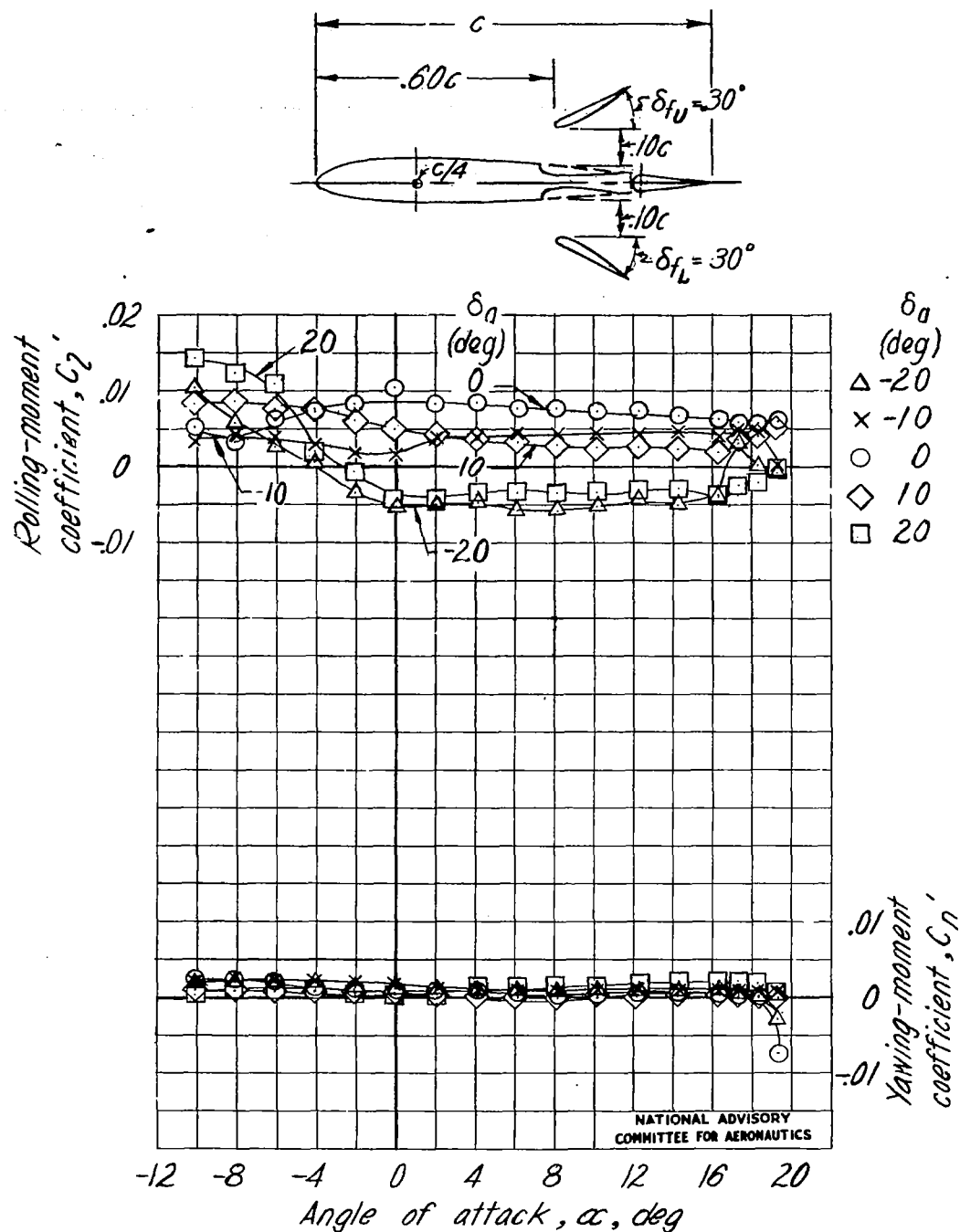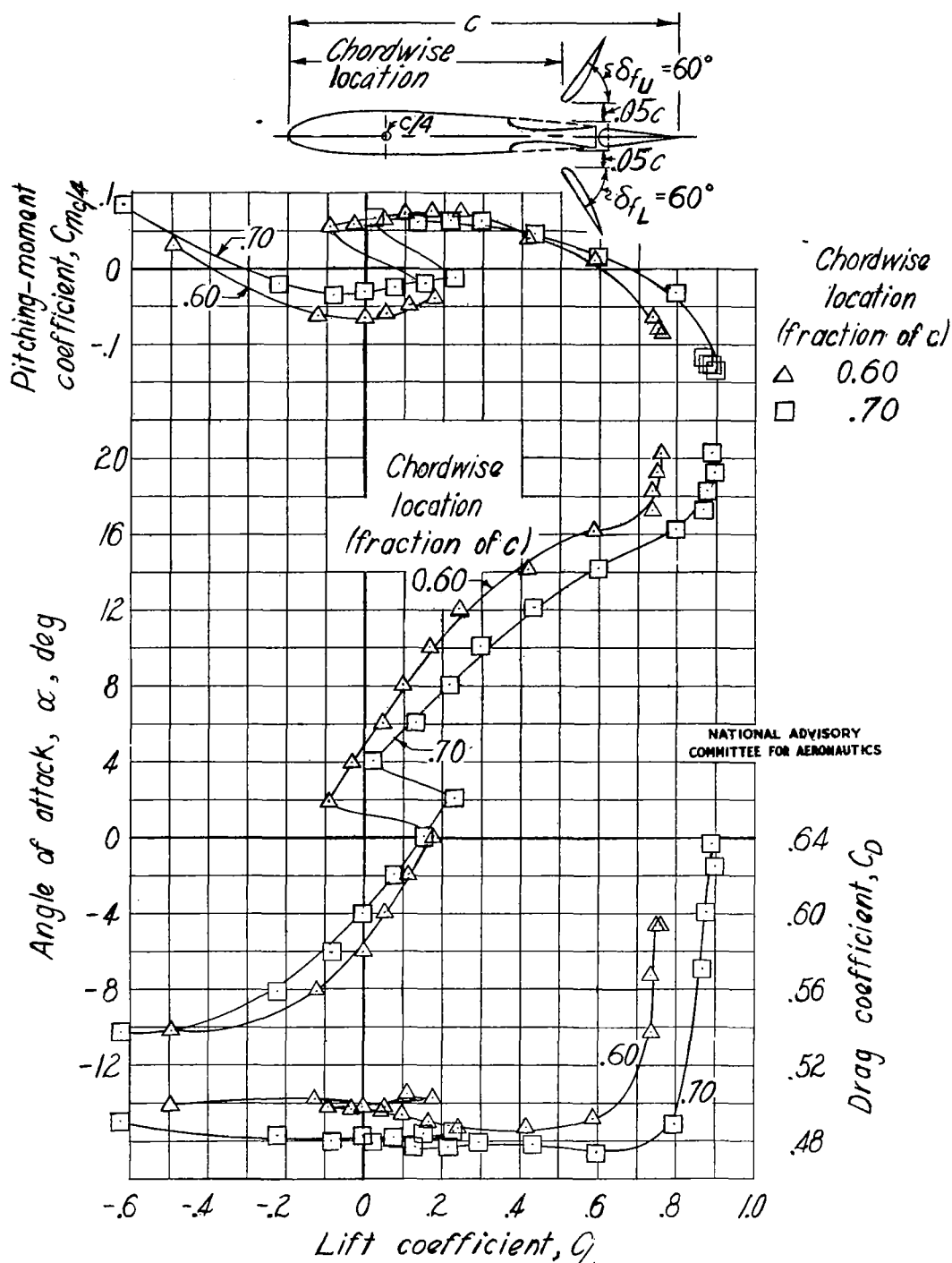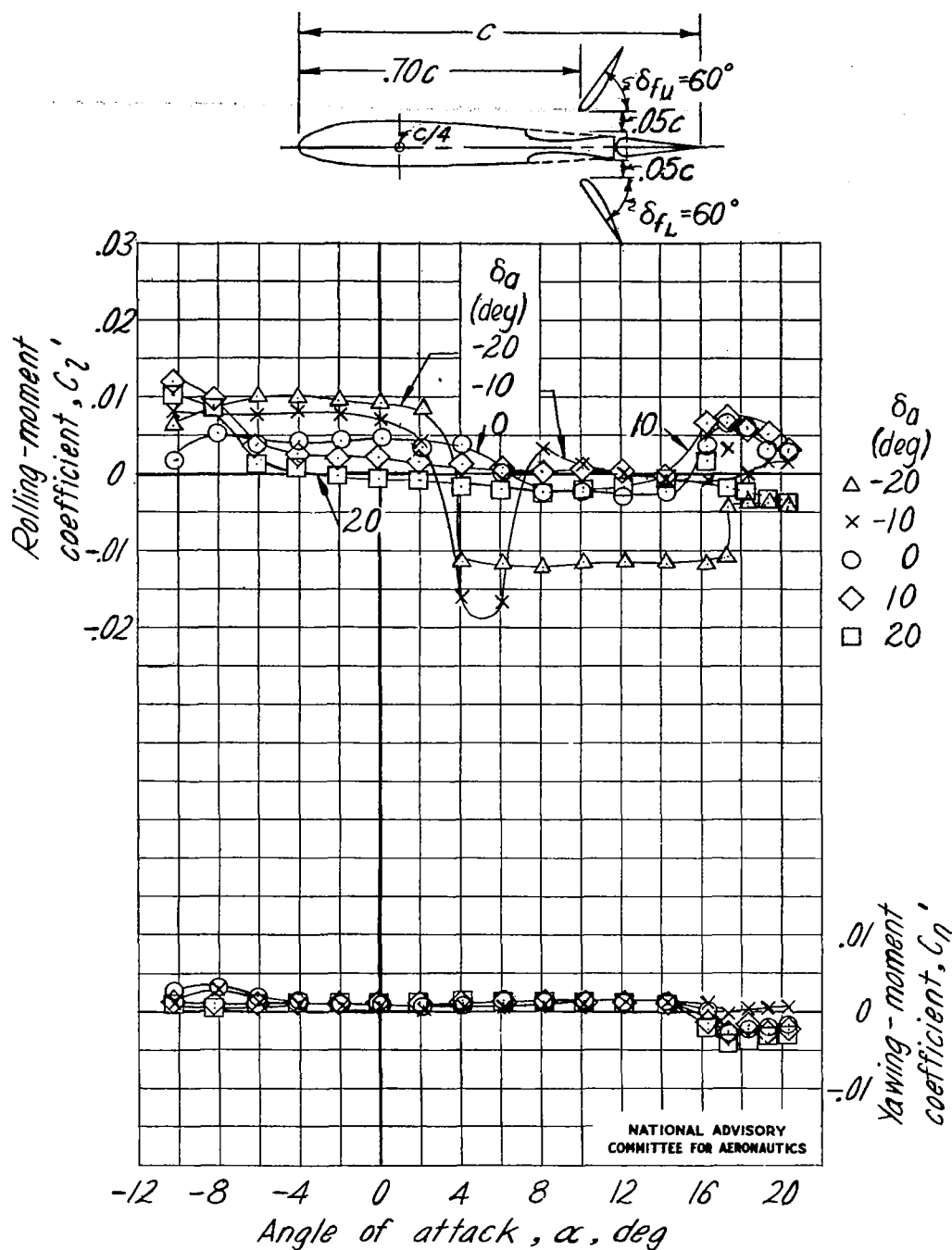
Figure 20.- Rolling- and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having flat-plate sections. Chordwise location,0.90c; gaps,0.20c.

(a) δ_{f_U} and δ_{f_L}, 60°.

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS.

(b) δ_{f_U} and δ_{f_L}, 120°

Figure 20.- Concluded.

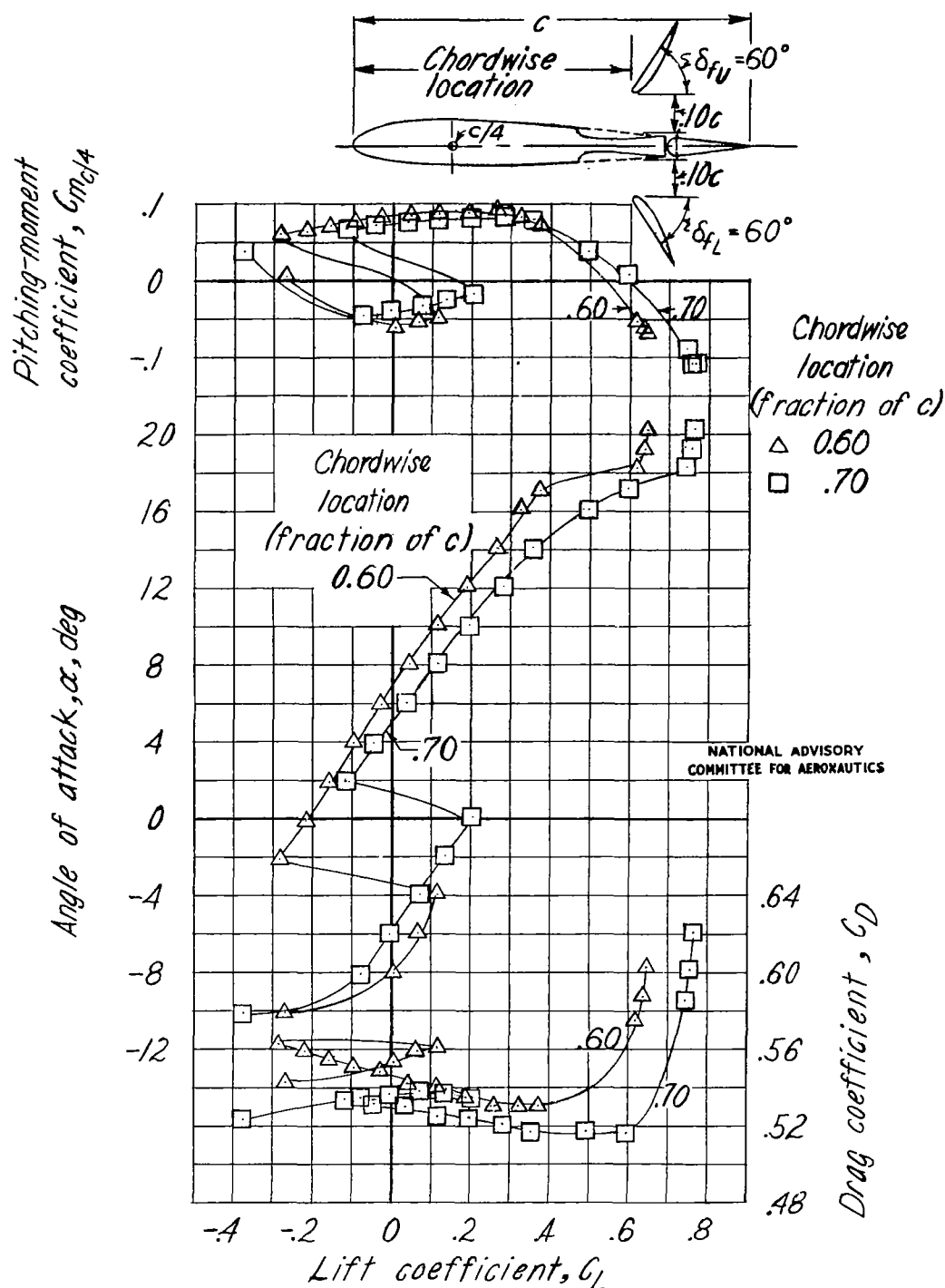Fig. 21   NACA ARR No. L5B17

Figure 21.- Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced single and double split flaps having flat-plate sections. Chordwise location, 0.80c; gaps, 0.10c; δ_a, 0°; δ_{f_U} and δ_{f_L}, 60°.
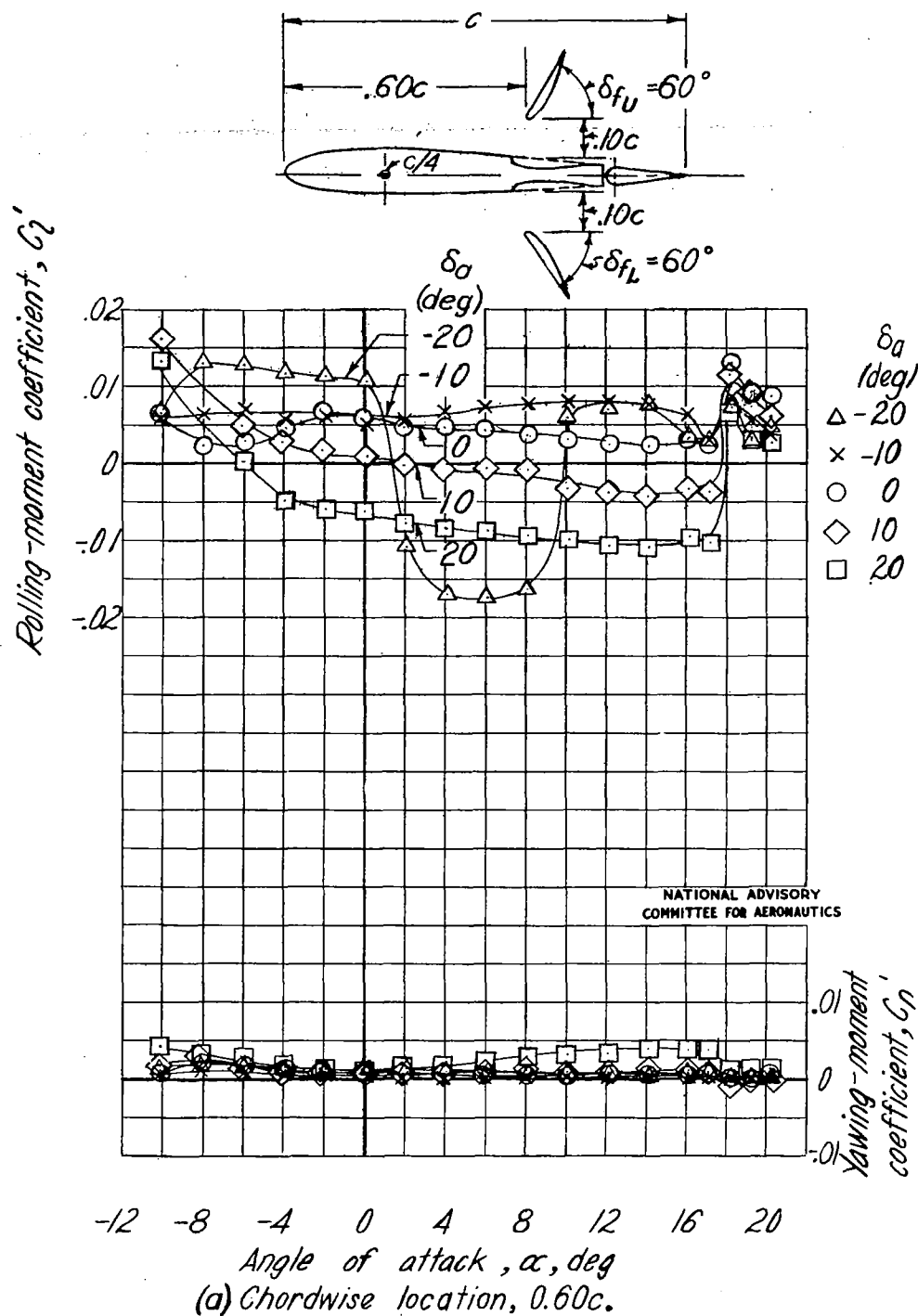
(a) Upper flap removed; δ_{f_L}, 60°.

Figure 22.– Rolling–and yawing–moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced single split flap having flat-plate section. Chordwise location, 0.80c; gap, 0.10c.

(b) Lower flap removed; δ_{f_u}, 60°.

Figure 22.- Concluded.

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

(a) Gaps, 0.05c.
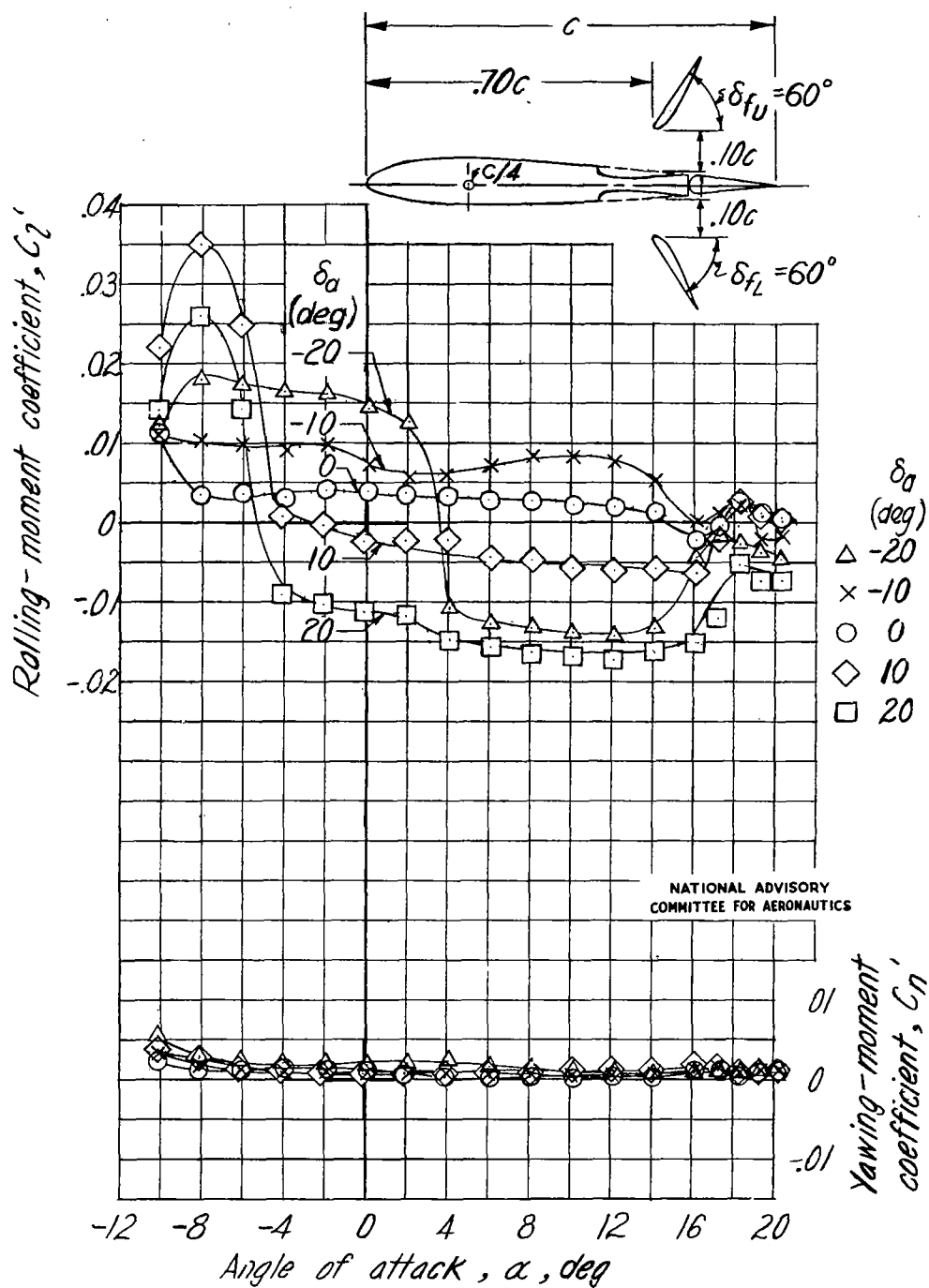
Figure 23.- Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. δ_a, 0°; δ_{f_U} and δ_{f_L}, 30°.

(b) Gaps, 0.10c.

Figure 23.- Concluded.

Figure 24.- Rolling-and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. Chordwise location, 0.60c; gaps, 0.10c; δ_{f_U} and δ_{f_L}, $30°$.

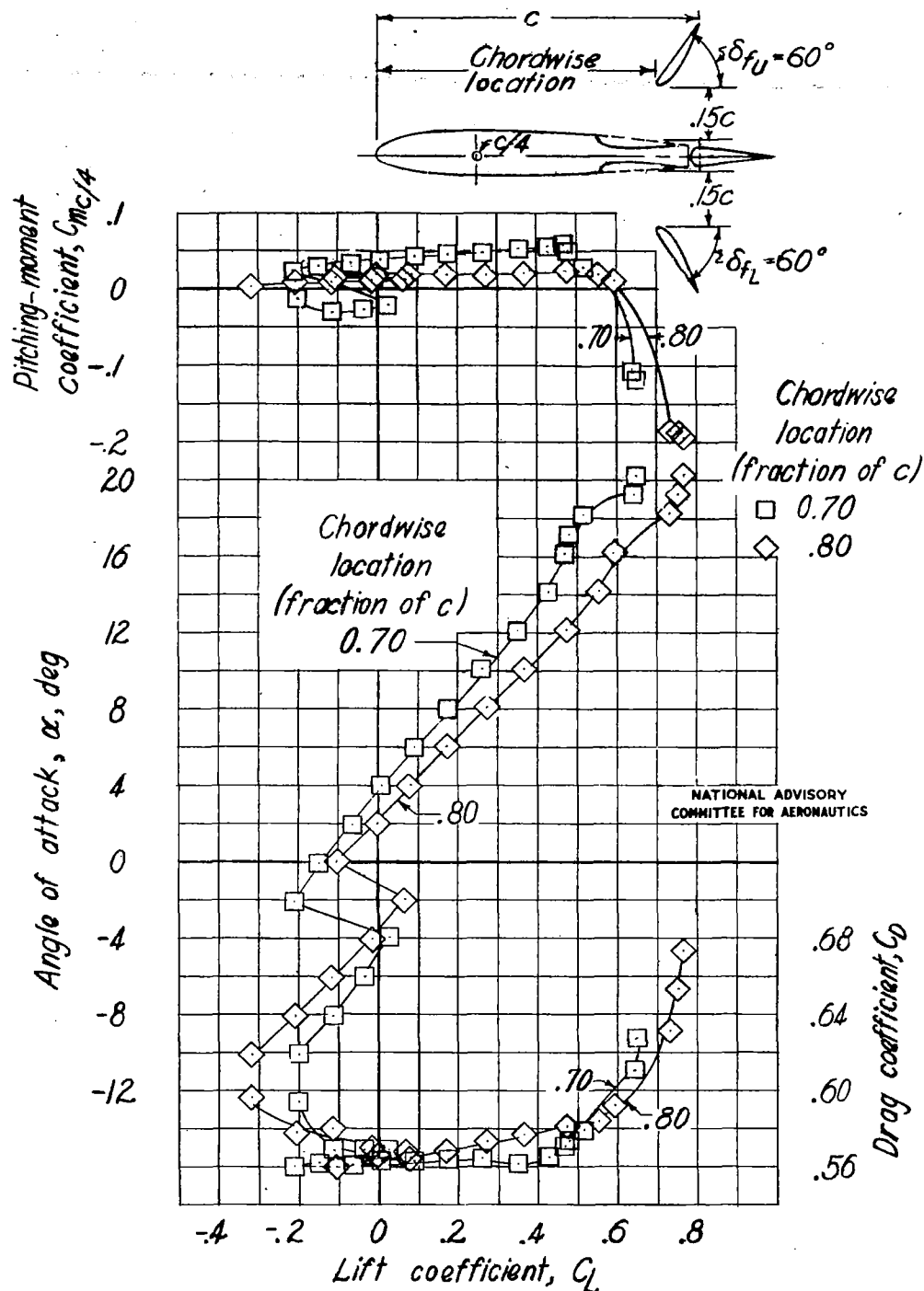Fig. 25   NACA ARR No. L5B17

Figure 25.-Lift, drag, and pitching-moment characteristics of the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. Gaps, 0.05c; δ_a, 0°; δ_{f_U} and δ_{f_L}, 60°.
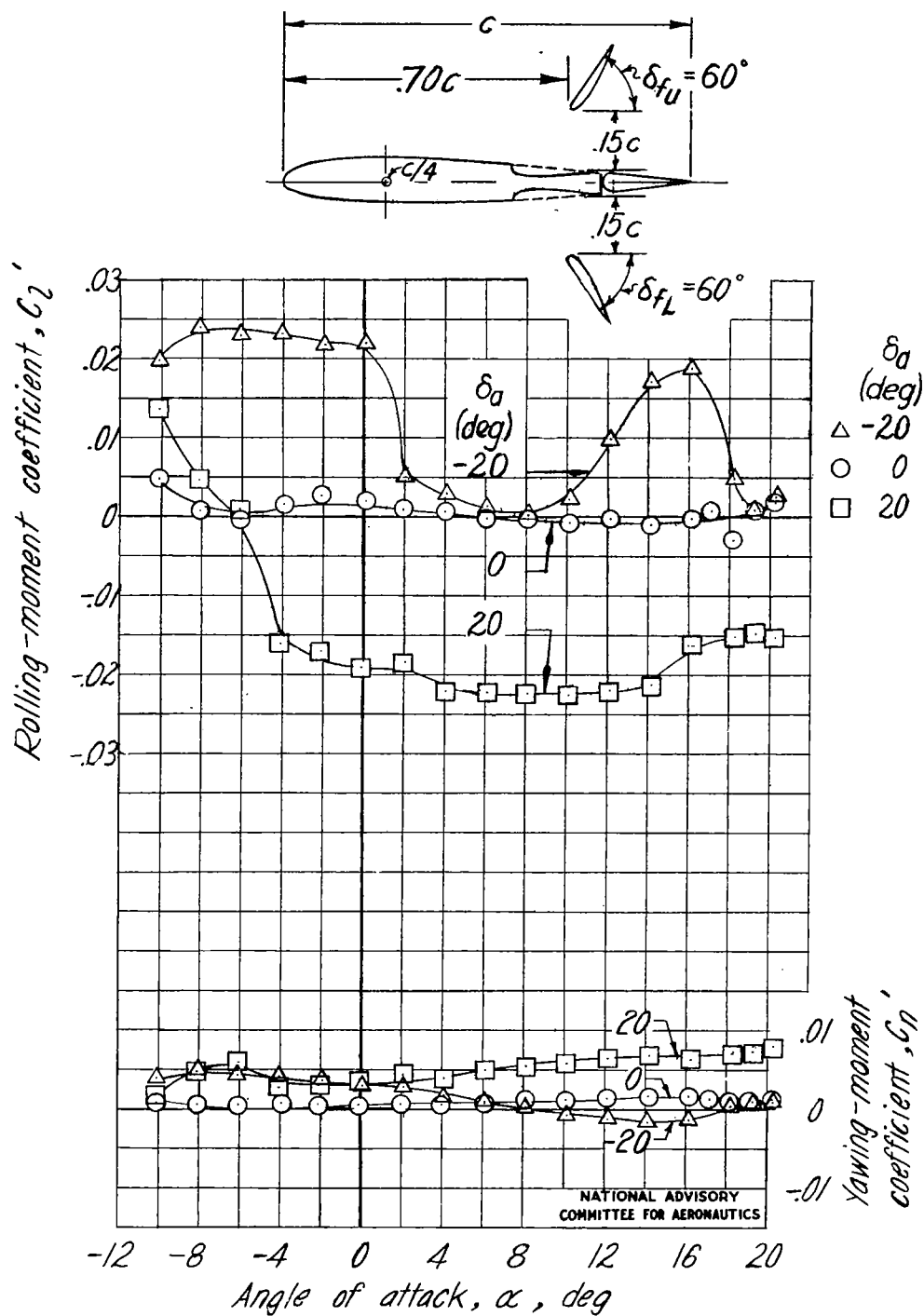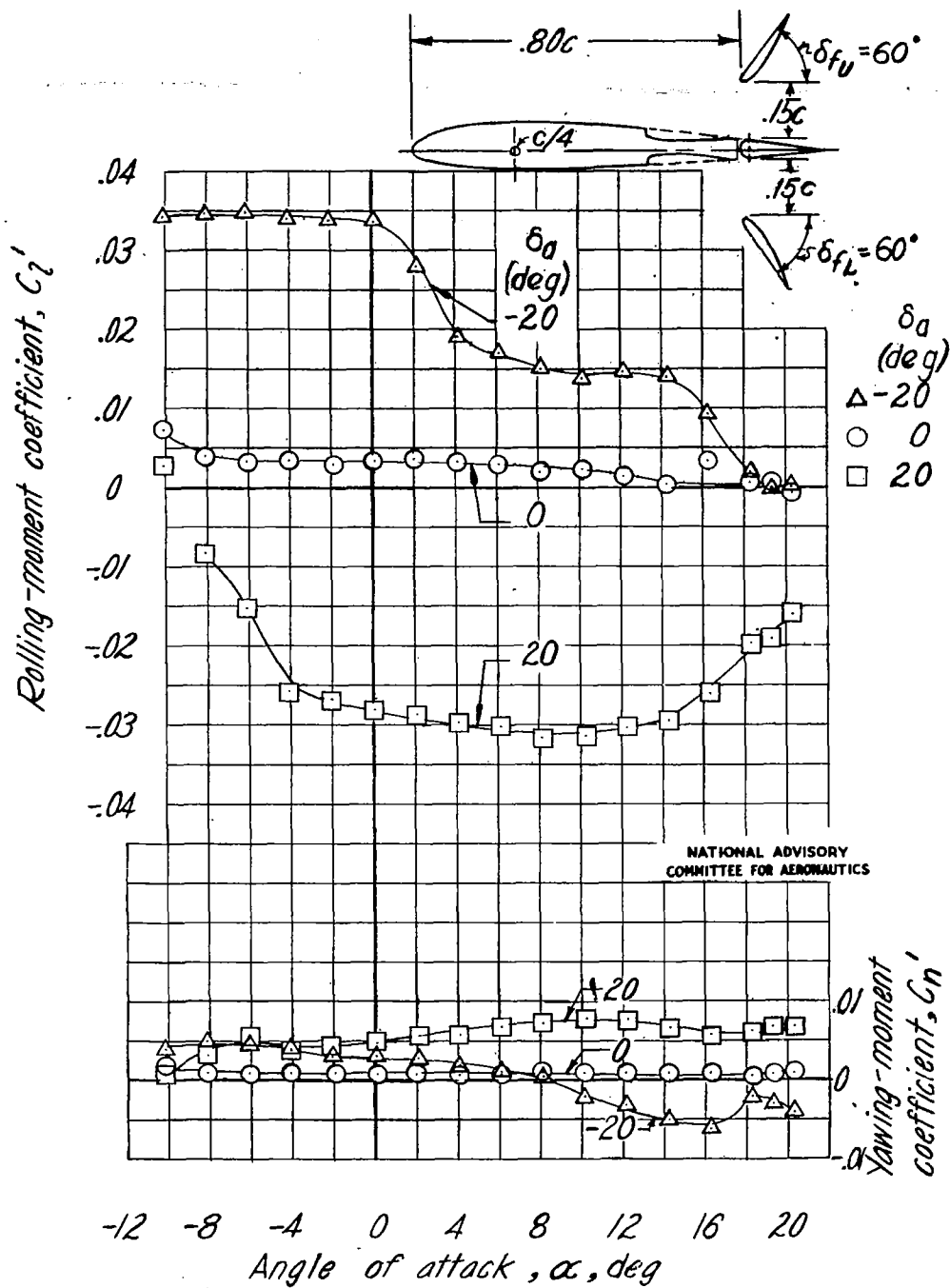
Figure 26.-Rolling-and yawing-moment characteristics of
the right semispan aileron on the NACA 2212 wing
model equipped with balanced double split flaps
having Clark Y sections. Chordwise location, 0.70c;
gaps, 0.05c; δ_{f_U} and δ_{f_L}, 60°.

Fig. 27   NACA ARR No. L5B17
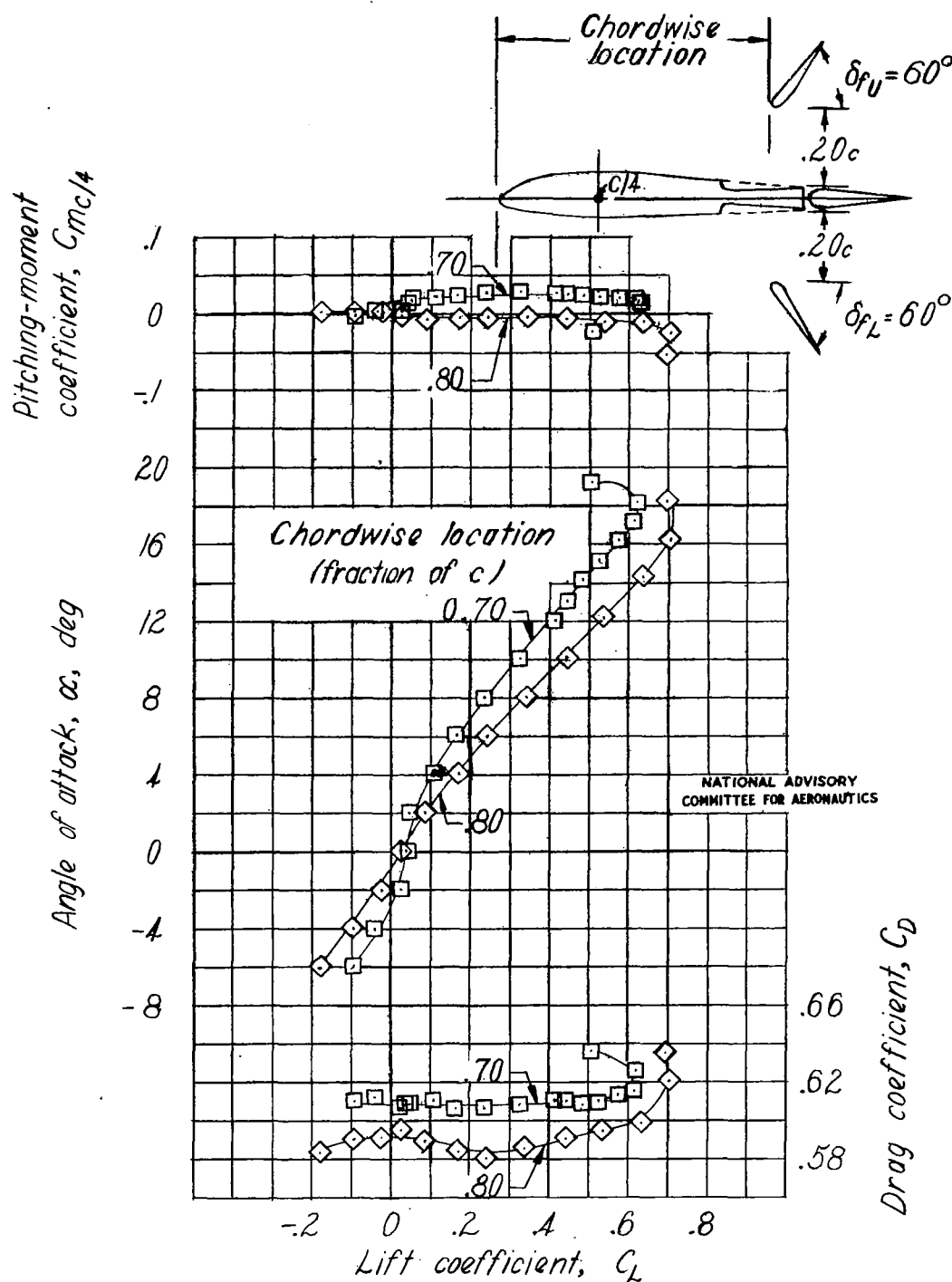

Figure 27.— Lift, drag, and pitching-moment characteristics
of the NACA 2212 wing model equipped with balanced
double split flaps having Clark Y sections. Gaps, 0.10c;
δ_a, $0°$; δ_{f_U} and δ_{f_L}, $60°$.
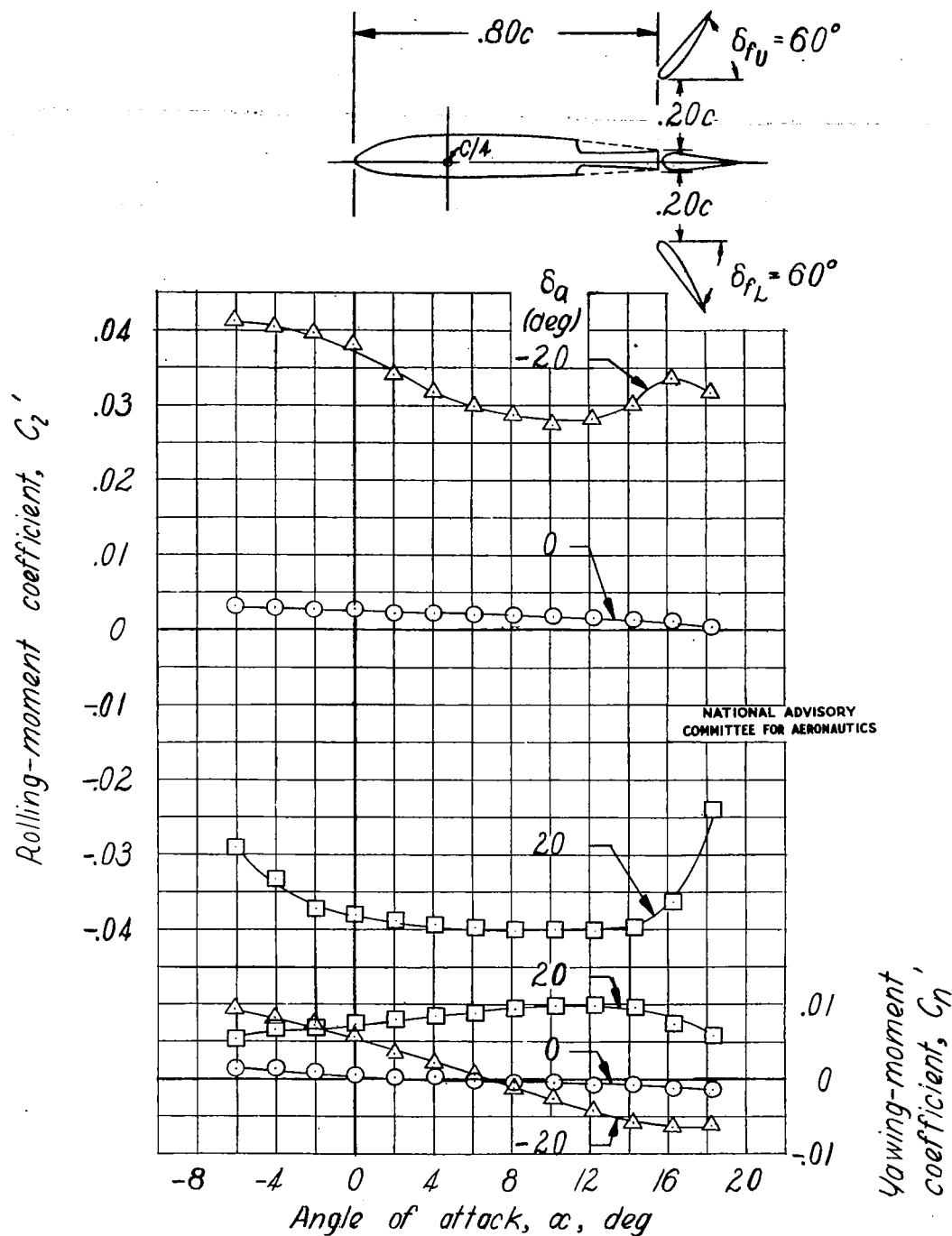
(a) Chordwise location, 0.60c.

Figure 28.- Rolling-and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. Gaps, 0.10c; δ_{f_U} and δ_{f_L}, 60°.

(b) Chordwise location, 0.70c.

Figure 28.- Concluded.

Figure 29 – Lift, drag, and pitching-moment characteristics
of the NACA 2212 wing model equipped with balanced
double split flaps having Clark Y sections. Gaps, 0.15c;
δ_a, 0°; δ_{f_U} and δ_{f_L}, 60°.

(a) Chordwise location, 0.70c.

Figure 30.- Rolling-and yawing-moment characteristics
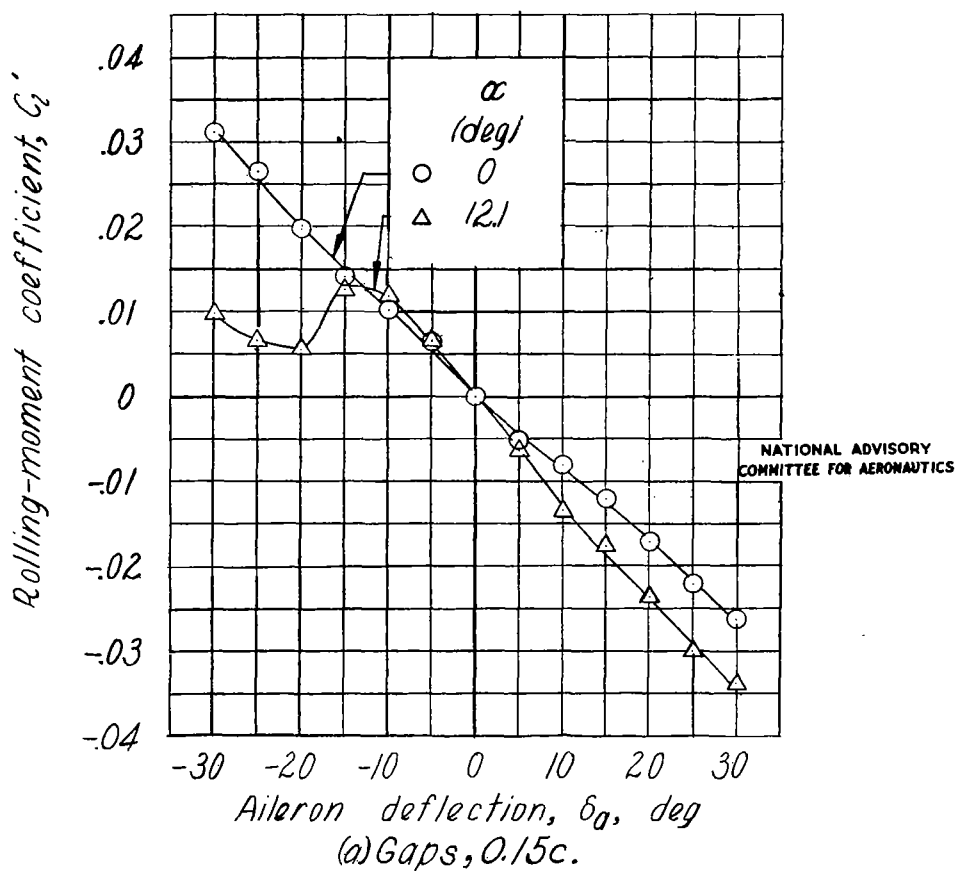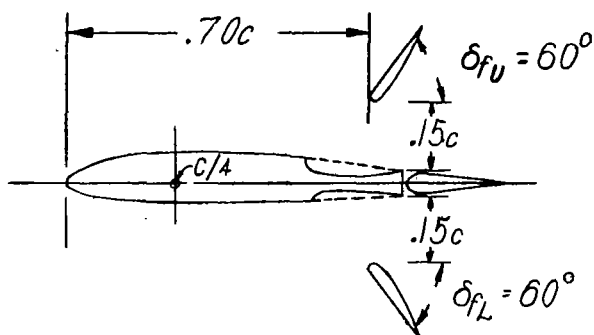of the right semispan aileron on the NACA 2212
wing model equipped with balanced double split flaps
having Clark Y sections. Gaps, 0.15c; δ_{f_U} and δ_{f_L}, 60°.

(b) Chordwise location, 0.80c.

Figure 30.— Concluded.

Fig. 31   NACA ARR No. L5B17

Figure 31.- Lift , drag , and pitching-moment characteristics
of the NACA 2212 wing model equipped with balanced
double split flaps having Clark Y sections.
Gaps, 0.20c; δ_a, 0° , δ_{f_U} and δ_{f_L}, 60°.

Figure 32.- Rolling- and yawing-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. Chordwise location, 0.80c; gaps, 0.20c; δ_{f_U} and δ_{f_L}, 60°.

$\delta_{f_U} = 60°$

$.70c$

$.15c$

$c/4$

$.15c$

$\delta_{f_L} = 60°$

α
(deg)

○   0

△   12.1

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

Rolling-moment coefficient, C_l'

Aileron deflection, δ_a, deg

(a) Gaps, 0.15c.

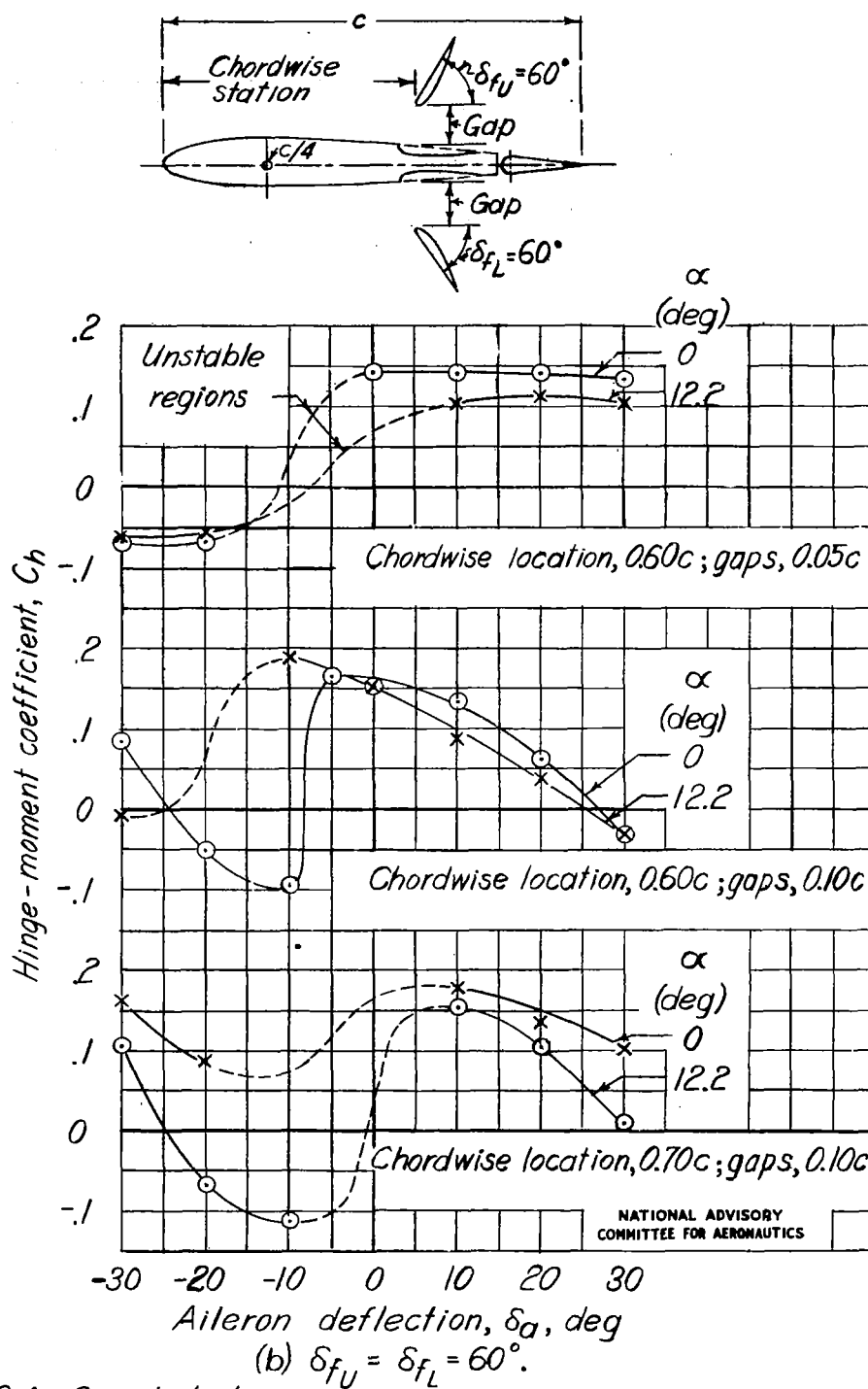Figure 33.-Rolling-moment characteristics of the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. Chordwise location, 0.70c; δ_{f_U} and δ_{f_L}, 60°.
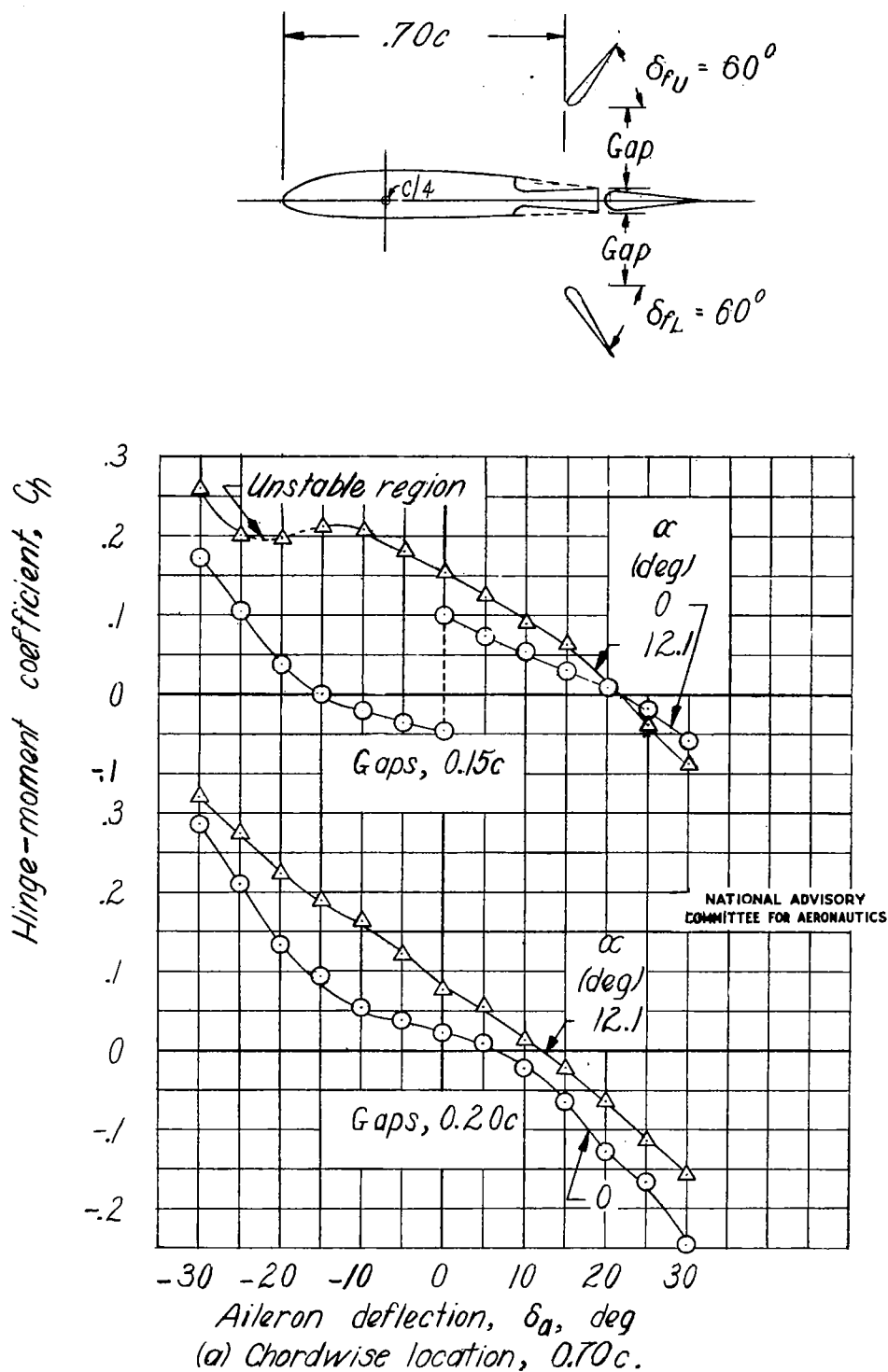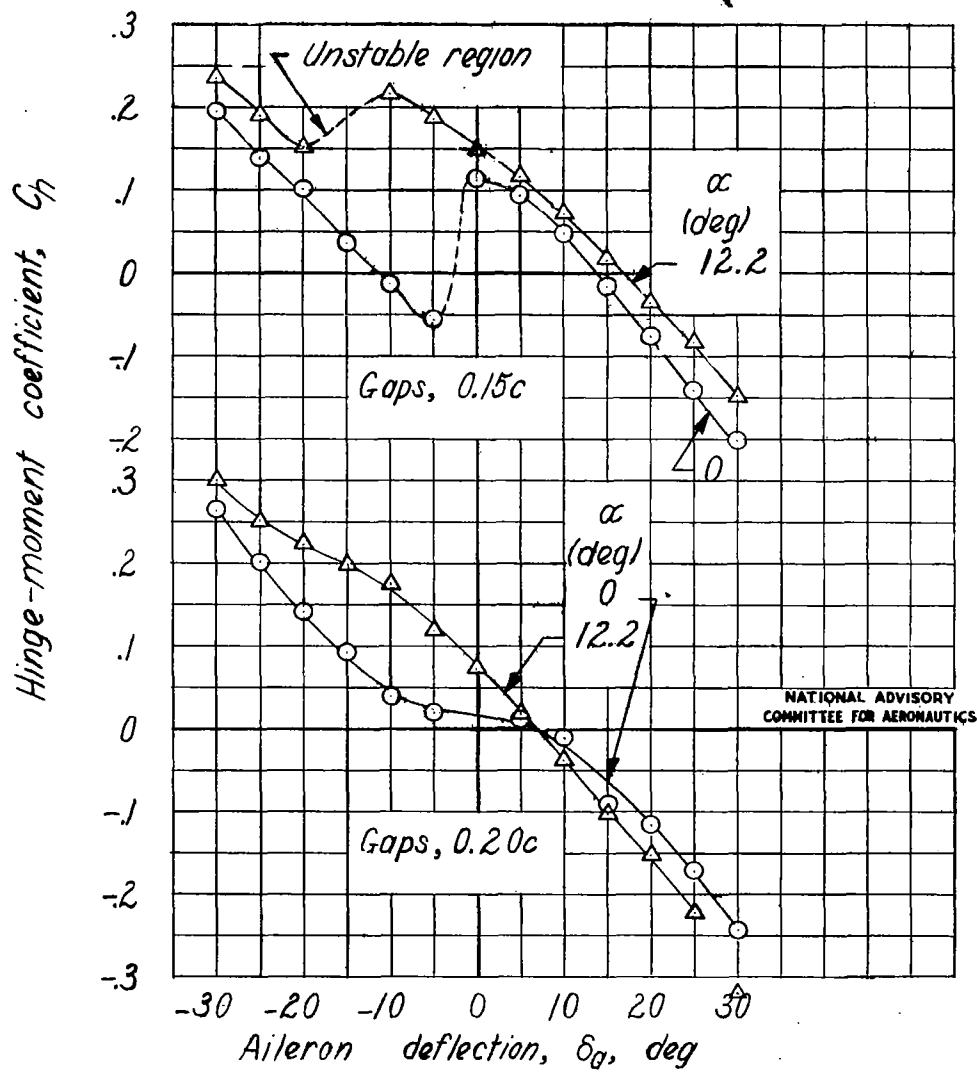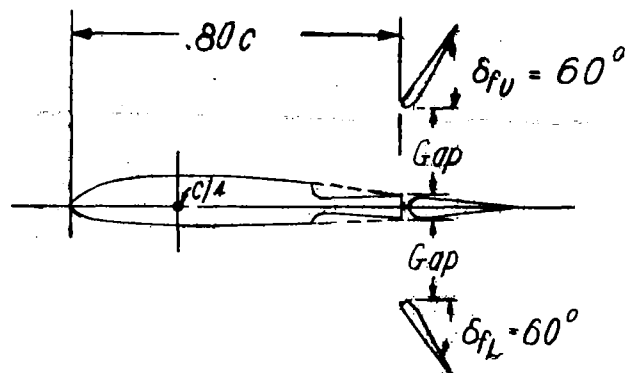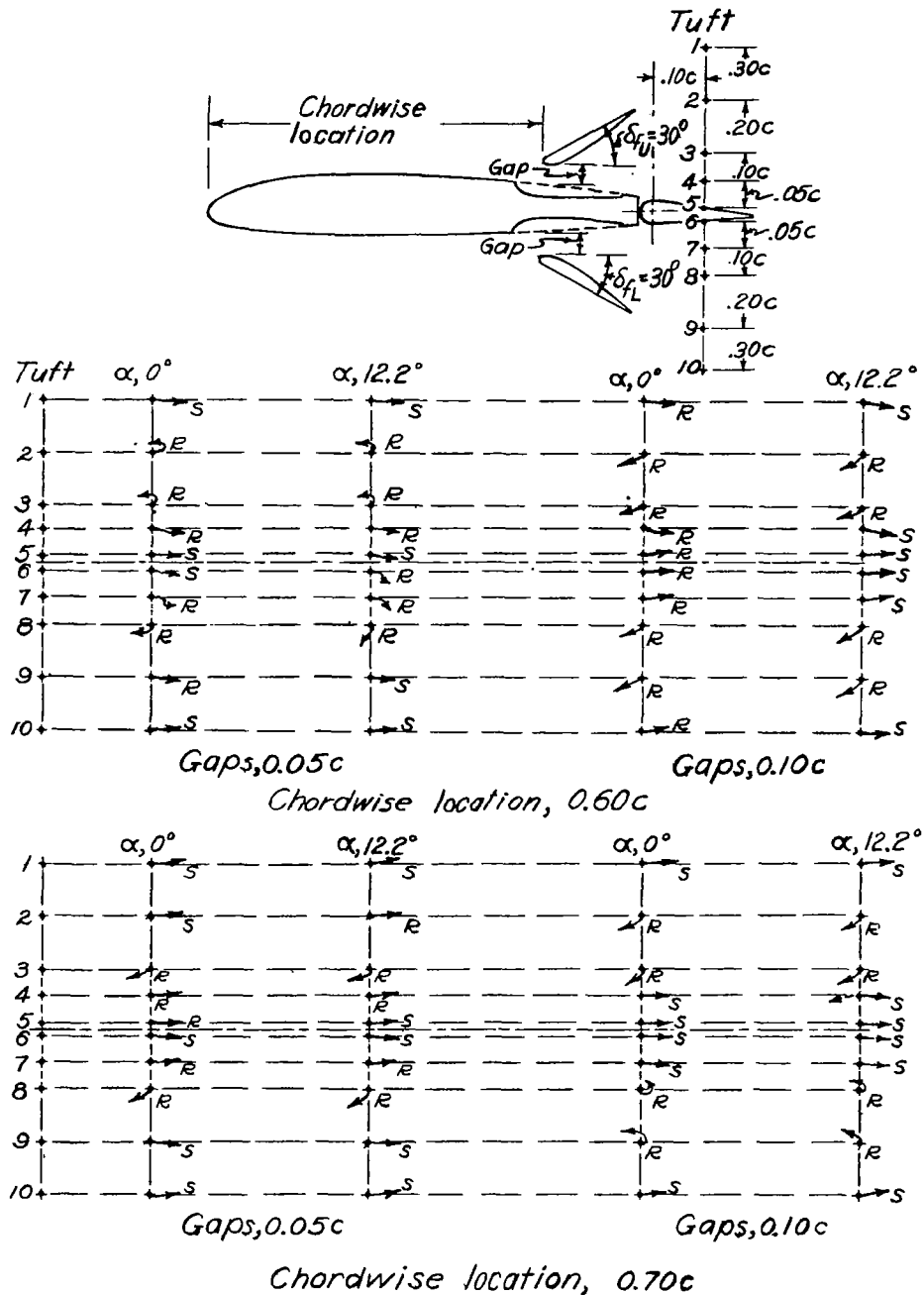
(b) Gaps, 0.20c.
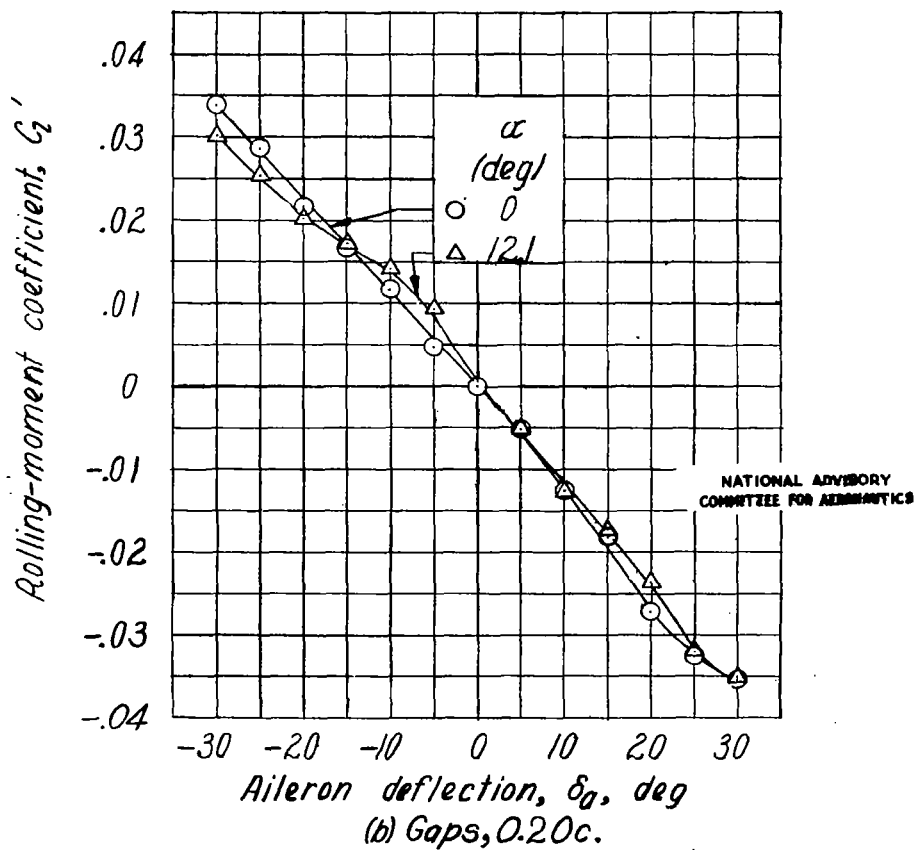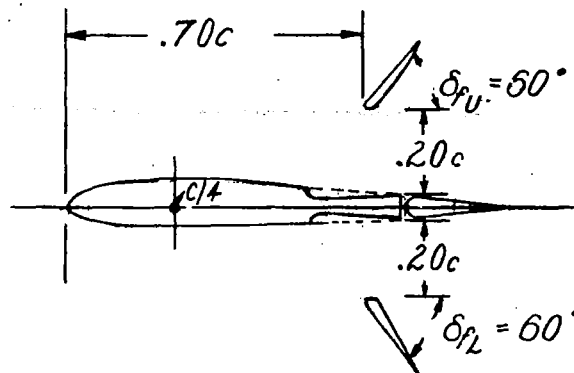
Figure 33.- Concluded.
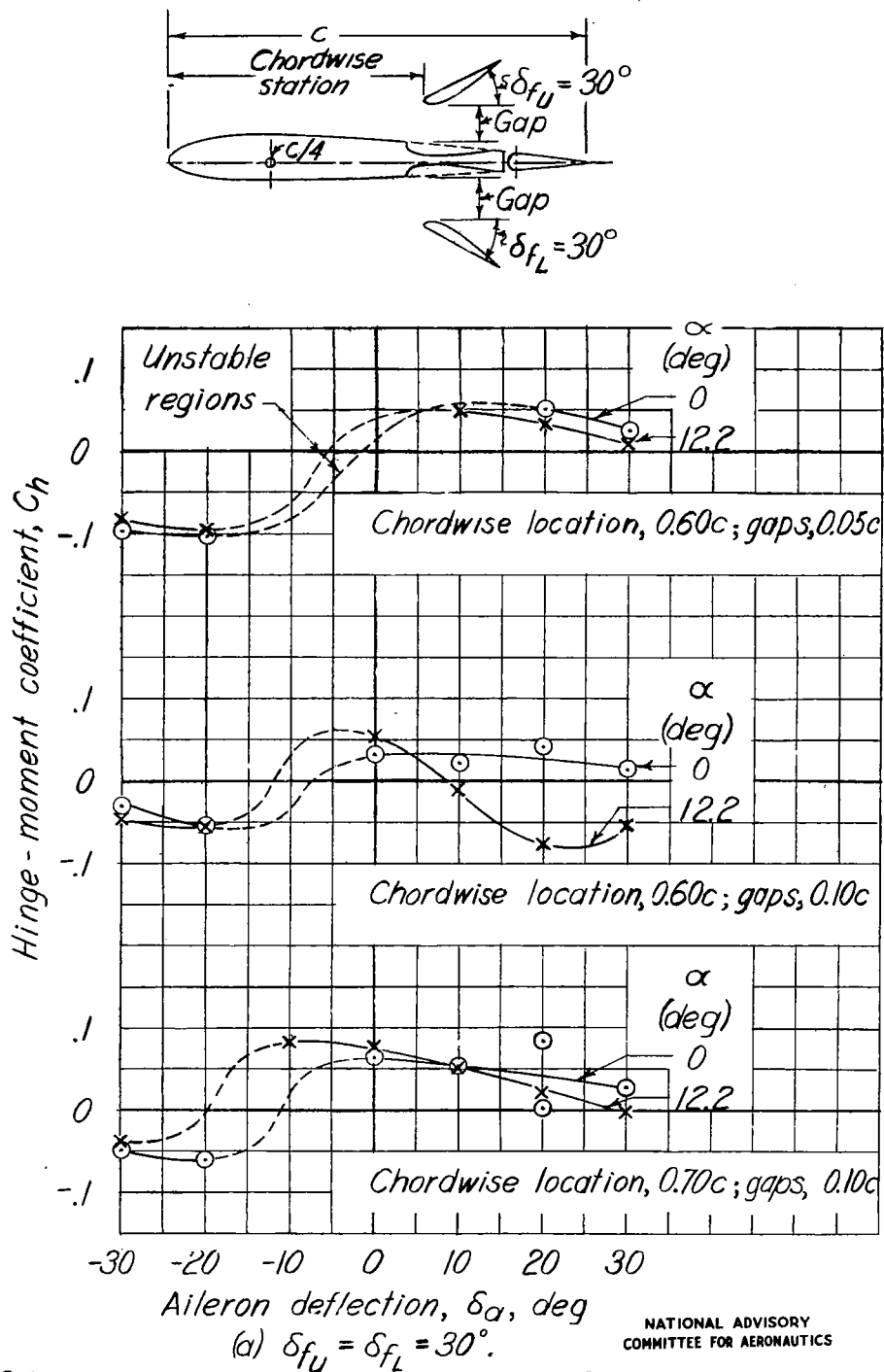
Figure 34.-Hinge-moment characteristics of the right
semispan aileron on the NACA 2212 wing model equipped
with balanced double split flaps having Clark Y sections.

(b) $\delta_{f_U} = \delta_{f_L} = 60°$.

Figure 34.- Concluded.

(a) Chordwise location, 0.70c.

Figure 35.-Hinge-moment characteristics of the right semi-span aileron on the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. δ_{fU} and δ_{fL}, 60°.

(b) Chordwise location, 0.80c.

Figure 35.- Concluded.

(a) $\delta_{f_u} = \delta_{f_L} = 30°$.

Figure 36.- Tuft study of flow conditions above and below the right semispan aileron on the NACA 2212 wing model equipped with balanced double split flaps having Clark Y sections. Tufts located at aileron midspan; S indicates smooth flow; R indicates rough flow.
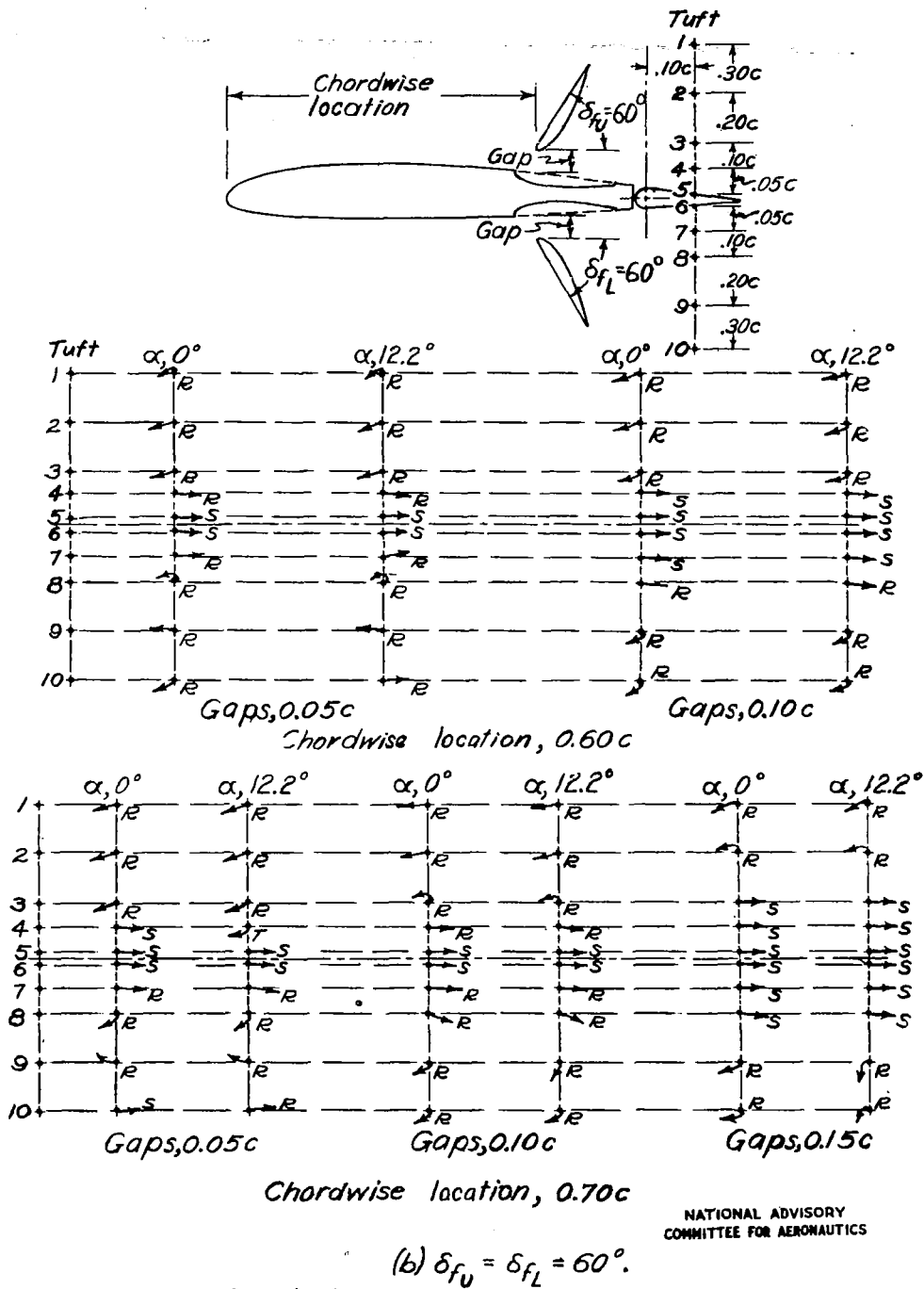
(b) $\delta_{f_U} = \delta_{f_L} = 60°$.

Figure 36.- Concluded.

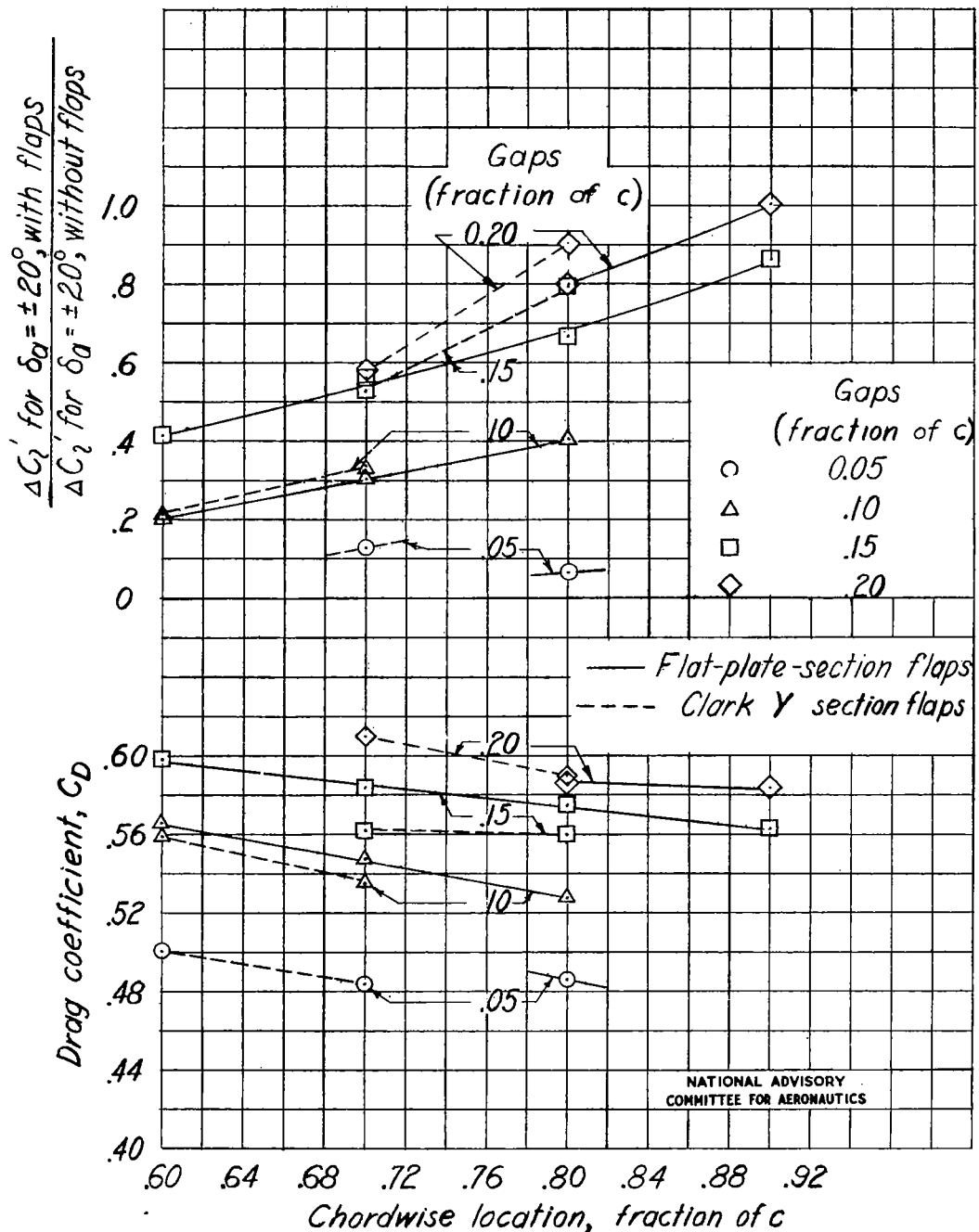Fig. 37   NACA ARR No. L5B17

Figure 37.- Effect of chordwise location and gaps on the drag coefficients and the aileron effectiveness of the NACA 2212 wing model equipped with balanced double split flaps having flat-plate or Clark Y sections. $\alpha, 0°; \delta_{f_u}$ and $\delta_{f_L}, 60°$.